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MARINE SAFETY PRECAUTIONS

Throughout this manual you will notice WARNING and CAUTION symbols which alert you to potentially dangerous conditions to the operator, service personnel, or the equipment itself.

WARNING **Onan uses this symbol throughout the text to warn of possible injury or death.**

CAUTION **This symbol is used to warn of possible equipment damage.**

Before operating the generator set, read the operator's manual and become familiar with it and your unit. Safe and efficient operation can be achieved only if the unit is properly operated and maintained. Many accidents are caused by failure to follow simple and fundamental rules or precautions.

- Do not fill fuel tanks with the engine running. Do not smoke around generator set area. Wipe up any oil or gas spills. Do not leave oily rags in engine compartment or on the generator set. Keep this and surrounding area clean.
- Equip the engine fuel supply with a positive fuel shutoff for a remote fuel supply source.
- Provide adequate ventilation (preferably power exhausters) to expel toxic gas fumes and fuel vapors from the engine compartment. Be sure propulsion and generator engine exhaust systems are free of leaks.
- Perform thorough, periodic inspections of the exhaust system and repair leaks immediately. Exhaust gases are deadly.
- Coolants under pressure have boiling points over 212 F (100 C). Do not open a coolant pressure cap while the engine is running. Always bleed off the system pressure first.
- Do not remove any belt guards or covers with the unit running.
- Keep hands and loose clothing away from moving parts. Do not wear jewelry while servicing any part of the generator set.
- Never step on the generator set (as when entering or leaving the engine compartment). It can stress and break unit components, possibly resulting in dangerous operating conditions . . . from leaking fuel, leaking exhaust fumes, etc.
- Before performing any maintenance on the set, disconnect its batteries to prevent accidental starting. Disconnect the ground lead first. Do not smoke while servicing batteries. Hydrogen gas given off during charging is explosive. Make sure you connect the battery correctly. A direct short across the battery terminals can cause an explosion. Connect the ground lead last.
- Do not make adjustments in the control panel or on engine with unit running. High voltages are present. If you must work around unit while it is running, stand on dry surfaces to reduce shock hazard.
- Keep a fire extinguisher available in or near the engine compartment and in other areas throughout the vessel. Use the correct extinguisher for the area. For most types of fires, an extinguisher rated ABC by the NFPA is available and suitable for use on all types of fires except alcohol.
- Onan suggests posting these suggestions in potential hazard areas of the vessel. Most important, exercise caution and use common sense.

INTRODUCTION

Every Onan marine model is designed, built and tested specifically for marine service. Many features such as radio suppression, full-pressure lubrication, hard faced valves and seats, low oil pressure and high water temperature cut-out switches, drip pans, vibration dampeners, neoprene impeller water pumps to name a few are standard.

All features, necessary to provide dependable day-in, day-out electric power aboard your vessel are built into every Onan marine unit.

Standard models are available in 1, 2, or 4 cylinder gasoline or diesel engines in sizes up to 50 kW. There are three main types of cooling systems available. Direct water cooling, heat exchanger cooling using two separate water systems, and keel cooling using a closed water system.

The contents of this training manual are assembled with three specific objectives in mind.

1. To aid the instruction in teaching this material.
2. A means of self instruction for student learning.
3. A dual purpose guide to be used with available slides to assist the instructor and as a future reference for the student to use when necessary.

The purpose of this training manual in covering marine service is to give the student a general over-all knowledge of all aspects of service and to enable the service personnel to become proficient in many areas of marine service such as:

- Installation
- Theory of Operation
- Adjustments
- Preventive Maintenance
- Troubleshooting
- Controls
- Rules and Regulations

For all Onan electric generating sets, engine end is the front, generator end is the rear. Right and left sides are determined by facing the set from the engine (front) end.

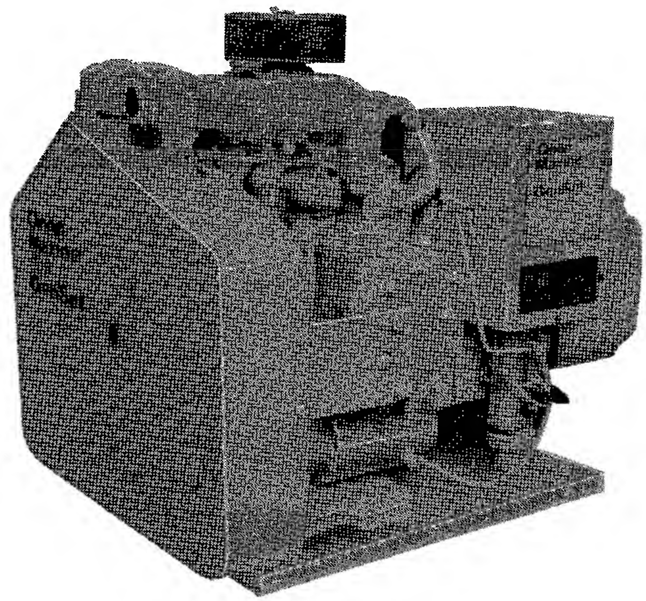
The following pages contain a general description by model of the size and features of the various units covered in this manual. Reference is made throughout the manual to various other Onan publications which deal specifically with one area of this manual in detail and will serve to supplement the information contained in this manual.

All metric dimensions are given in parentheses following the U.S. customary unit.

All information, illustrations and specifications contained in this manual are based on the latest product information available at the time of publication. Onan reserves the right to make changes at any time without notice.

GENERAL DESCRIPTION

MARINE SERIES 4.0 AND 6.5 MCCK - 4,000 or 6,500 WATTS



The 4.0 and 6.5 kW MCCK is a 4-cycle, two cylinder horizontally opposed, water cooled 1800 rpm engine. The 4-pole, self-excited revolving armature generator is inherently regulated. The sets have a mounted control box, and may be connected to optional equipment for remote starting or automatic load demand start-stop controls.

These units meet all the USCG 183 requirements.

MODEL SELECTION AND RATING TABLE

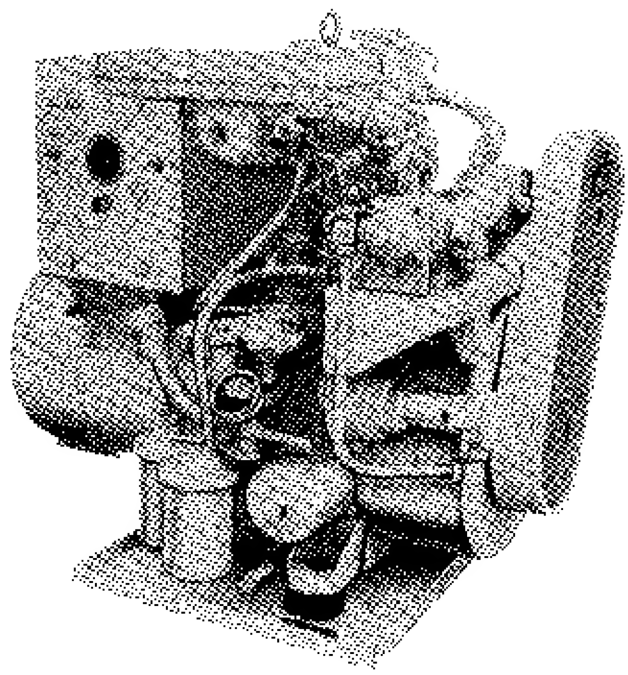
MODEL NUMBER	GENERAL MARINE RATING							ENGINE	
	VOLTS	AMPS	kW	kVA and PF	PHASE	WIRE	HERTZ	RPM	STARTING
4.0MCCK-3CR*	120/240	33/17	4	4.0 at 1.0 PF	1	4	60	1800	Remote
6.5MCCK-3CR*	120/240	54/27	6.5	6.5 at 1.0 PF	1	4	60	1800	Remote

* - These models are connected 120-240-volt, 3-wire and are reconnectible to deliver rated output at 120-volt, 2-wire or 240-volt, 2-wire.

MARINE SERIES 3.0MDJA - 3,000 WATTS

The 3.0MDJA is a 4-cycle, single cylinder, vertical design, water cooled 1800 rpm generator set. The 4-pole, self excited revolving armature generator is inherently regulated, and is a starting motor for the engine. The illustration is a unit with optional heat exchanger cooling.

This model cannot be operated in a gasoline environment unless installed per USCG regulation 183.410.



MODEL SELECTION AND RATING TABLE

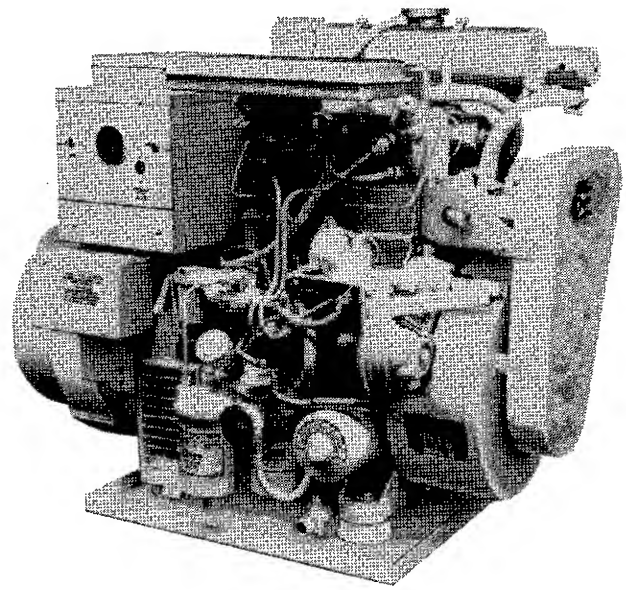
MODEL NUMBER	GENERAL MARINE RATING						REMOTE START
	VOLTS	AMPS	KW	PHASE	WIRE	HERTZ	
3.0MDJA-IR	120	25	3	1	2	60	12-volt
3.0MDJA-3CR*	120/240	12.5	3	1	4	60	12-volt

*Reconnectible to deliver rated output at 120-volt, 2-wire, 240-volt, 2-wire or 120/240-volt, 3-wire.

MARINE SERIES 6.0 and 7.5 kW MDJE

This diesel is a 4-cycle, two cylinder, overhead valve, 1800 rpm, vertical in line design water cooled engine, driving a revolving field generator. The new models are solid state voltage regulated. Older models are Magneciter (static) excited.

This model cannot be operated in a gasoline environment unless installed per USCG regulation 183.410.



MODEL SELECTION AND RATING TABLE

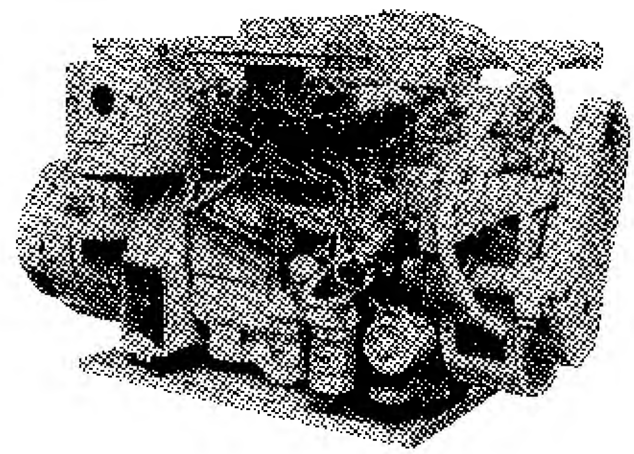
MODEL NUMBER	GENERAL MARINE RATING							REMOTE START
	VOLTS	AMPS	KW	KVA and PF	PHASE	WIRE	HERTZ	
6.0MDJE-53CR*	120/240	50/25	6.0	6.0 at 1.0PF	1	4	50	12-volt
6.0MDJE-518R**	—	—	6.0	7.5 at 0.8PF	3	4	50	12-volt
7.5MDJE-3CR*	120/240	64/32	7.5	7.5 at 1.0PF	1	4	60	12-volt
7.5MDJE-18R**	—	—	7.5	9.37 at 0.8PF	3	4	60	12-volt

* - These 120/240-volt models are reconnectible to deliver full rated output at 120-volt, 2-wire or 240-volt, 2-wire.
** - This is a 12 lead, broad range reconnectible alternator which user connects for required voltage and amperage.

MARINE SERIES 12.0 MDJC and 15.0 MDJF

This series is a 4-cycle, four cylinder, overhead valve, vertical in-line design, water cooled 1800 rpm engine, driving a revolving field generator. The new models are solid state voltage regulated. Older models are Magneciter (static) excited.

This model cannot be operated in a gasoline environment unless installed per USCG regulation 183.410.



MODEL SELECTION AND RATING TABLE

MODEL NUMBER	GENERAL MARINE RATING							REMOTE START
	VOLTS	AMP	KW	KVA and PF	PHASE	WIRE	HERTZ	
12.0MDJF-53CR	120/240*	100/50	12	12.0 at 1.0PF	1	4	50	12-volt
12.0MDJC-3CR	120/240*	100/50	12	12.0 at 1.0PF	1	4	60	12-volt
15.0MDJF-3CR	120/240*	125/62.5	15	15.0 at 1.0PF	1	4	60	12-volt
15.0MDJF-3CR4	120/240*	100/50	15	15.0 at 1.0PF	1	4	60	12-volt

* These 120/240-volt models are reconnectible to deliver full rated output at 120-volt, 2-wire or 240-volt, 2-wire.

SECTION I
INSTALLATION

- Introduction
- How To Estimate Electrical Load
- Mounting and Location
- Ventilation Requirements
- Exhaust Systems
- Fuel Systems
- Cooling Systems
- Batteries
- Summary (Practice Safety)

WHAT IS A GOOD MARINE INSTALLATION?

A boat owner considers the marine electric generating set well installed if it supplies electricity quietly, safely and efficiently.

The installation must be safe. The United States Coast Guard, National Fire Protection Association and American Boat and Yacht Council have established safety standards which you should always follow. All installations must be made to conform with the applicable standards.

Our recommendations for the proper installation of a marine electric set are based on years of experience in the manufacture of generator sets. We offer these recommendations through this training manual so you can be assured the Onan unit selected for your boat will operate quietly and efficiently for many years to come. For further recommendations see Technical Bulletin T-021.

HOW TO ESTIMATE THE ELECTRICAL LOAD

To determine the correct size or model Onan marine set required for the vessel, total the wattage of all the equipment and appliances which will be operated at the same time. Usually the wattage is available on the nameplates of the equipment and appliances. If the amperage is given, multiply the amperage by the voltage to get the wattage. If the wattage or amperage is not given on your appliances, use the watt loads shown below for estimating purposes.

The electric generating set selected must be capable of supplying maximum load during starting for each motor and continuous load when motors are running. Motor, incandescent lamps and many other loads require several times full load current (inrush current) under starting conditions. If the motor loads are large, voltage dip may cause lights to dim or relays to chatter because of the starting load of some motors. When determining the size of the unit, consider the fact that electricity usage has doubled approximately every ten years. Consideration should be given to future electrical requirements necessary because of additional equipment being added to the vessel. Characteristics of conductors, effects of voltage drops, normal ampere ratings of the generating set and correct wire sizes are factors to be considered for almost all installations.

CIRCUIT BREAKERS: Onan recommends that fuses or circuit breakers be installed to protect the generator windings in case of an overload due to unbalanced loads or a short circuit in one of the load circuits. The 4.0 kW and 6.5 kW MCCK models are self limiting and do not require extra circuit protection.

BALANCE ALL LOADS: Divide the loads you intend to operate at one time equally between the generator output leads. The current loads for any one output lead must not exceed the nameplate rating. Overloading either output lead can damage the generator windings. Even though the generator outputs are affected, the engine has enough reserve power so it will not be sensitive to unbalanced loads.

It may be easier to understand why generator load circuits must be balanced if you think of a generator as having two legs (windings). Heavily loading one leg of the generator may result in higher than normal voltage outputs from the lighter-loaded leg as the generator attempts to offset the unbalanced loads.

MOTOR LOADS

Motors and motor driven applicances require up to five times more wattage while starting than while running. When figuring total watt requirements for motors, take five times the running watt rating of the largest motor and add the running watt ratings of all the smaller motors. This general listing applies to capacitor-start motors.

Motor Size	Starting	Running
1/6 horsepower	900 watts	200 watts
1/4 horsepower	1300 watts	300 watts
1/3 horsepower	1500 watts	360 watts
1/2 horsepower	2200 watts	520 watts
3/4 horsepower	3400 watts	775 watts
1 horsepower	4000 watts	1000 watts

Repulsion-induction motors require less starting wattage than capacitor-start motors, split-phase motors require more starting wattage than capacitor start motors.

Universal motors run satisfactorily on AC or DC.

APPLIANCE AND EQUIPMENT LOADS

Air Conditioner	See Motor Loads
Battery Chargers (Rectifier)	Up to 800watts
Blankets (electric)	50 to 200 watts
Coffee makers	550 to 700 watts
Electric drill	See Motor Loads
Electric Range (Per Element)	550 to 1500 watts
Fans	25 to 75 watts
Fry pan	1000 to 1350 watts
Heater (space)	1000 to 1500 watts
Hot plate (per element)	350 to 1000 watts
Iron (electric)	500 to 1200 watts
Lights (AC)	as marked
Refrigerator	See Motor Loads
Television	200 to 300 watts
Toaster	800 to 1150 watts
Vacuum cleaner	See Motor Loads
Waffle iron	650 to 1200 watts
Water heater	1000 to 1500 watts
Electronic oven	750 to 1500 watts

MOUNTING

Onan marine electric generating sets are supplied with vibration isolator mounts and on some models, a drip pan. A mounting base must be prepared to mount the unit to engine stringers or other strong supports in the vessel. The base should be strong enough to support several hundred pounds, and withstand considerable vibration and shock effects such as rocking of the vessel in heavy seas. See Figure 1-1. Table 1-1 gives maximum operating angle of Onan marine units.

TABLE 1-1. MAXIMUM OPERATION ANGLE OF ONAN MARINE UNITS

ELECTRIC GENERATING SET	MAXIMUM OPERATION ANGLE (ANY DIRECTION)
MCCK, MDJA, MDJE	20°
MDJC, MDJF	30°

UNIT LOCATION

A generator set may be installed in the propulsion engine compartment if specific conditions are met.

U.S.C.G. regulation 183.410 requires a generator set operating in a gasoline fuel environment be "ignition protected". This is a set capable of operating in an explosive environment without igniting that environment.

Diesel generator sets are not required to meet the 183.410 regulation when used in a diesel fuel environment, but are not certified to operate in a gasoline fuel environment.

Most propulsion engine compartments are already ventilated, and have access to the fuel supply. Keep the generator set away from living quarters, and away from bilge splash and vapors. Select a location that will allow adequate space on all sides for servicing the set.

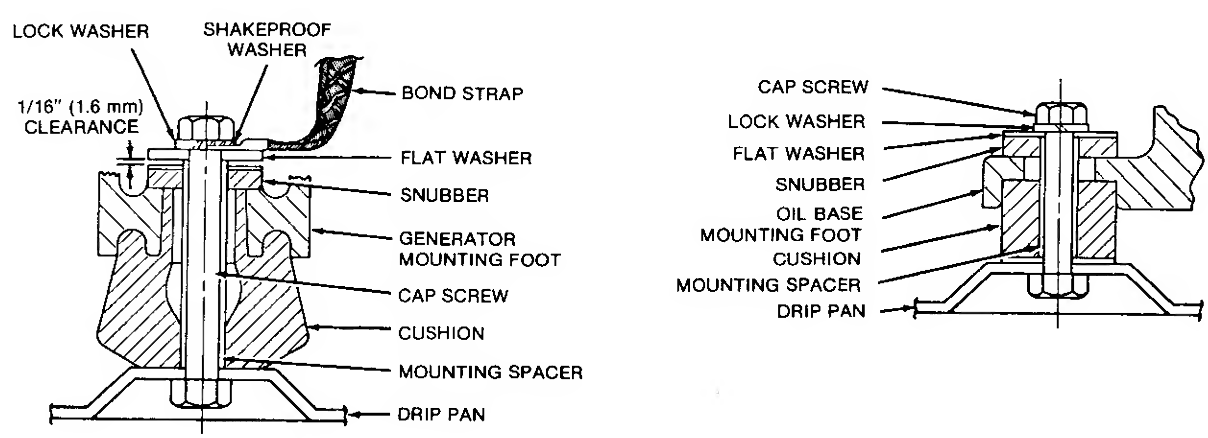


FIGURE 1-1. VIBRATION ISOLATORS

VENTILATION REQUIREMENTS

Electric generating sets must have free air circulation while operating to provide combustion air for the engine and cooling air for the generator. Table 1-3 lists minimum air requirements for Onan marine units.

If the generator set fuel tank is in a separate compartment, it should be ventilated the same as the engine compartment. For passenger vessels, the Coast Guard recommends a powered exhausting system to meet requirements as shown in Table 1-2. The airflow should be sufficient to prevent recirculation of generator cooling air.

TABLE 1-2. PASSENGER VESSEL VENTILATION REQUIREMENTS

SIZE OF COMPARTMENT IN CU. FT. (m^3)	MINUTES PER AIR CHANGE
Less than 500 (14)	2
500 to 1000 (14 to 28)	3
1000 to 1500 (28 to 42)	4
1500 (42) and Up	5

TABLE 1-3. AIR REQUIREMENTS CUBIC FEET PER MINUTE (m^3)

GENERATOR SET	GENERATOR COOLING AIR 1800 RPM	COMBUSTION AIR 1800 RPM	TOTAL
3.0MDJA	75 (2.1)	16 (0.5)	91 (2.6)
7.5MDJE	135 (3.8)	32 (1)	167 (4.7)
12.0MDJC, 15.0MDJF	125 (3.5)	64 (1.8)	189 (5.4)
4.0, 6.5MCCK	120 (3.4)	32 (0.9)	141 (4)

EXHAUST SYSTEM

GENERAL

All exhaust systems for water-cooled marine installations must meet these requirements:

1. Except for vertical dry stack systems, exhaust systems must be water cooled, the water injected as near to the generator set as possible.
2. All exhaust system sections preceding the point of cooling water injection must be either water jacketed or effectively insulated.
3. The exhaust line must be installed so as to prevent back flow of water to the engine under any conditions, and the exhaust outlet must be above the load waterline. Water flowing back to the engine will damage it.
4. The generator set's exhaust system must not be combined with the exhaust system of any other engine.
5. An approved, flexible, non-metallic exhaust line section should be used near the engine to allow for engine movement and vibration during operation.
6. Vertical dry stack exhaust systems must have spark arresters. The exhaust system between engine manifold and spark arrester must be either water jacketed or well insulated.
7. Be of sufficient size to prevent excessive back pressure.

WARNING **Use extreme care during exhaust system installation to ensure a tight exhaust system. Exhaust gases are deadly.**

MATERIAL

Use material recommended by ABYC in "Safety Standard for Small Craft", Section P1. The exhaust line should be at least as large as the engine exhaust outlet (Table 1-4).

Most installations today use flexible rubber hose for the water cooled section of the exhaust line for ease of installation and flexibility. Be sure the hose is designed and approved for marine exhaust line.

Provide adequate support for rubber hose to prevent sagging, bending and formation of water pockets. Use automotive type pipe hangers to keep vibration from transmitting to the hull. Two hose clamps having minimum width of 1/2 inch (12.7 mm) should be used at each end of hose. See Figures 1-2 and 1-3.

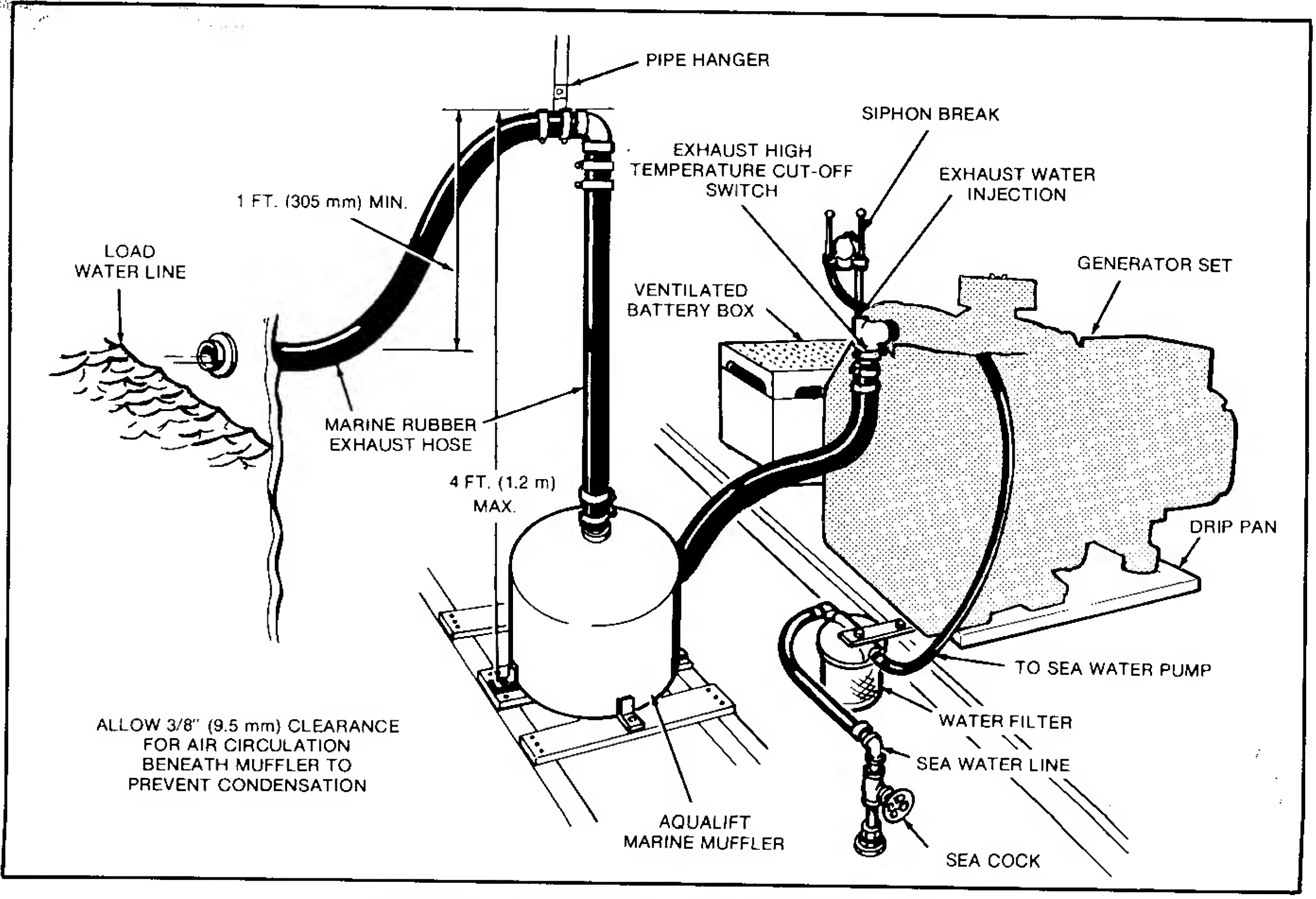


FIGURE 1-2. TYPICAL SMALL UNIT EXHAUST SYSTEM

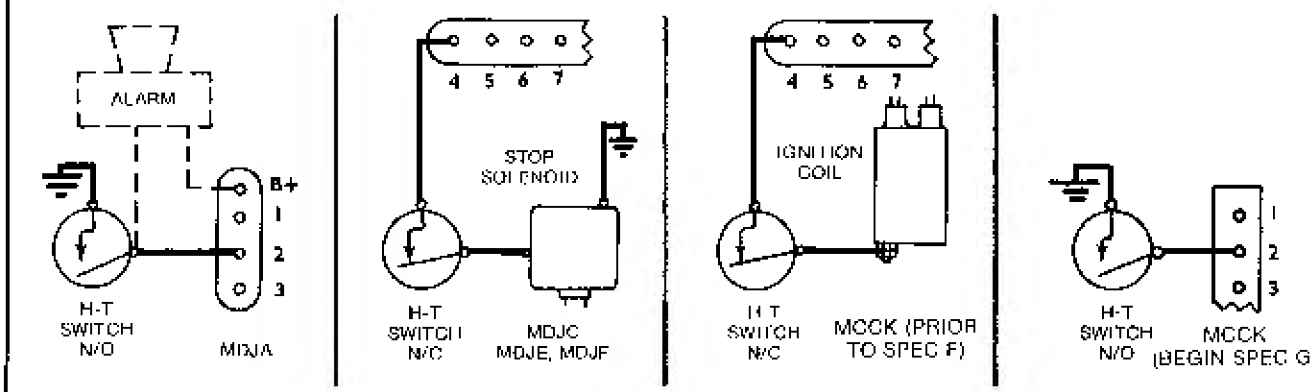
TABLE 1-4. ELECTRIC GENERATING SET EXHAUST OUTLET SIZES

UNIT MODEL	EXHAUST OUTLET SIZE (IN.)
MCCK Thru SPEC "G"	1
MDJA, MDJE, MCCK "H"	1-1/4
MDJC, MDJF	1-1/2

WARNING Don't use the manifold as a muffler support because it puts excessive strain on the connecting exhaust line and can cause it to break allowing poisonous exhaust fumes to escape.

To help break up the momentum of backwashing water in the exhaust lines before the water backflows to the engine, the muffler can be installed near the unit. Water rushing forward will pour into the muffler, dissipating its momentum.

WARNING Do not install rubber hose with sharp bends as this will reduce efficiency and may cause hose failure. Do not use rubber hose on dry type exhaust applications.



NOTE: If set has a high water temperature cut-off switch mounted on engine cylinder block, connect exhaust temperature cut-off switch in series.

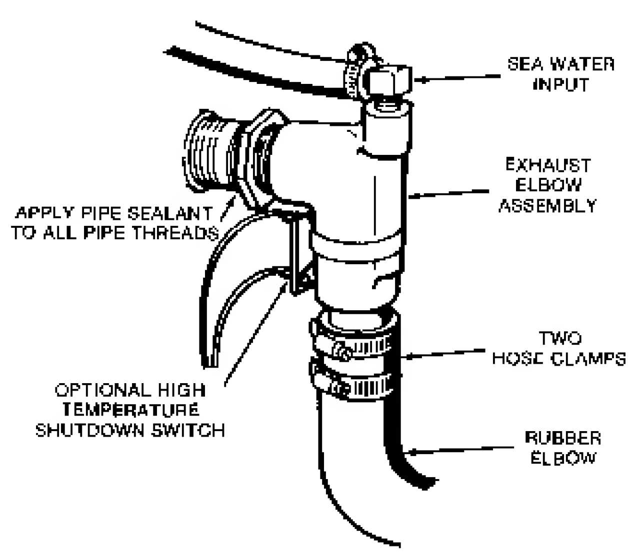


FIGURE 1-3. HIGH EXHAUST TEMPERATURE SHUTDOWN SWITCH

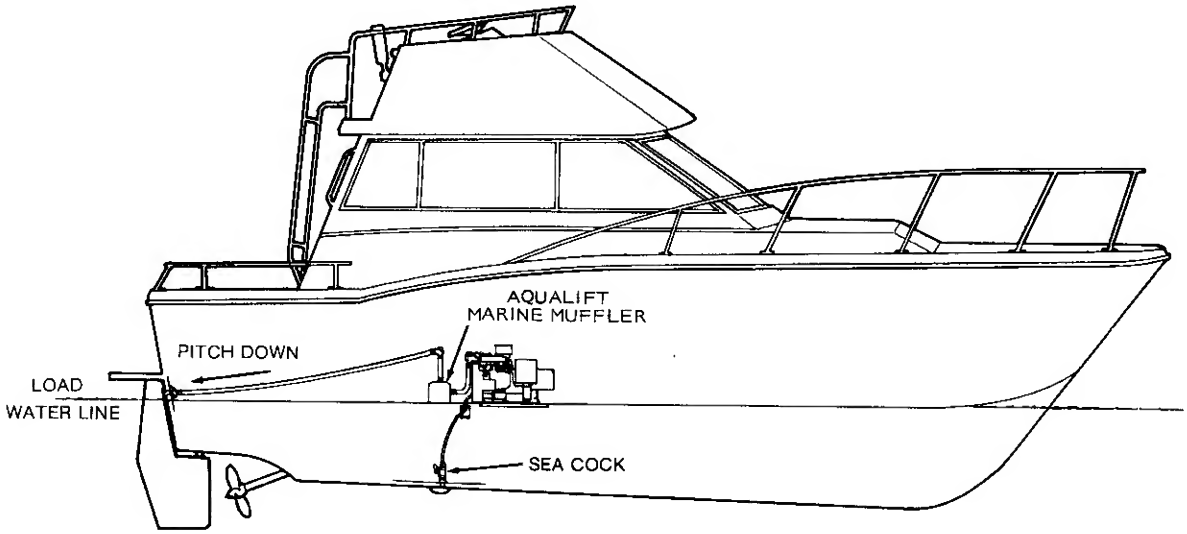


FIGURE 1-4. TYPICAL ABOVE WATER LINE INSTALLATION

EXHAUST COOLING WATER INJECTION

When installing a separate system to cool the exhaust, a device is required to indicate if the system fails. Mount a temperature operated switch on the exhaust elbow and connect it to operate either an alarm or to shut off the unit if the exhaust overheats (approximately 200°F (93°C). Onan recommends a high-temperature exhaust shutdown switches for all types of marine installations. See Figure 1-3.

An important consideration of water injection is keeping water from flowing back through the exhaust system into the engine. The two most frequent causes of water entering the engine are:

1. Momentum built by water sloshing in the exhaust line causing the water to rush forward into the engine when the boat pitches forward.
2. Engine stopping creates a vacuum and can draw water back into the engine.

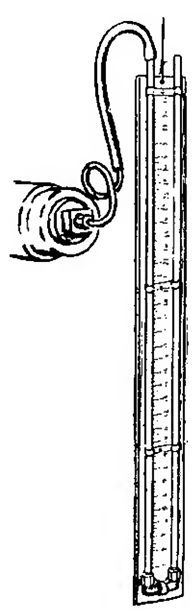
EXHAUST BACK PRESSURE

Exhaust back pressure is an important criteria of an adequate exhaust system. If the installation is excessively long or questionable, back pressure should be checked before putting the unit into operation. Most Onan marine electric generating sets with a separate water-cooled exhaust manifold have a 1/8 inch pipe-tapped hole with pipe plug on one end of the manifold. An adapter will have to be made to check back pressure on other Onan units.

Use a manometer or pressure gauge on the manifold to check back pressure. See Figure 1-5.

CAUTION **Excessive back pressure will cause loss of power.**

The exhaust back pressure ratings for the MDJF Series are considerably higher than those shown below. Consult your operator's manual for acceptable limits on the MDJF Series.



UNITS OF MEASUREMENT	BACK PRESSURE AT FULL LOAD
INCHES OF WATER	40
INCHES OF MERCURY	3
OUNCES/SQ. IN.	23.0 OZ.
KILOPASCAL	10

FIGURE 1-5. MANOMETER INSTALLATION

ONAN AQUALIFT MUFFLER

Onan recommends the Onan Aqualift muffler (Figures 1-6 and 1-7) for marine generator sets installed above or below the load water line. Because of installation variables, customers must provide the brackets, hoses and clamps required for installation. Complete instructions are included with the Aqualift muffler.

CAUTION If the Aqualift muffler is used, the hull strainer furnished with the muffler must be used. It is designed for this muffler to prevent back pressure or vacuum on the engine cooling system.

Be sure any muffler is well supported, and in the case of a neoprene muffler, completely separated from the vessel's structure. If a neoprene muffler touches the vessel, it increases exhaust noise.

Because the Aqualift has relatively little water in it during normal operation, it doesn't have to be drained for winter conditions. Freezing temperatures will not damage it.

CAUTION DO NOT USE SCOOP TYPE WATER INLET FITTINGS when installing an Aqualift muffler. Forward facing scoops develop sufficient ram pressure to force water past the set's water pump, flooding the exhaust system where it may flow back, flooding the engine cylinders. This can happen only if the electric set is not running and vessel is underway.

WARNING Welding on the muffler will damage the interior protective coating decreasing the life expectancy.

WARNING Be sure all fittings are tight to prevent poisonous exhaust fumes from escaping.

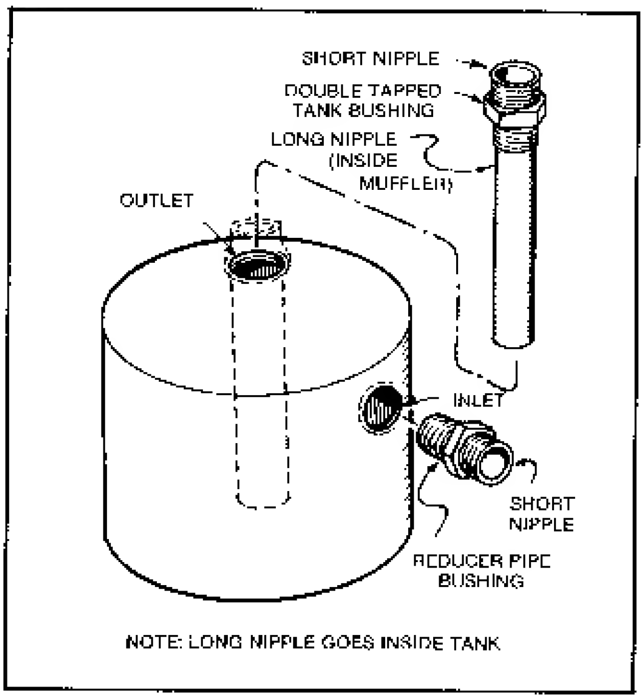


FIGURE 1-6. AQUALIFT MUFFLER CONSTRUCTION

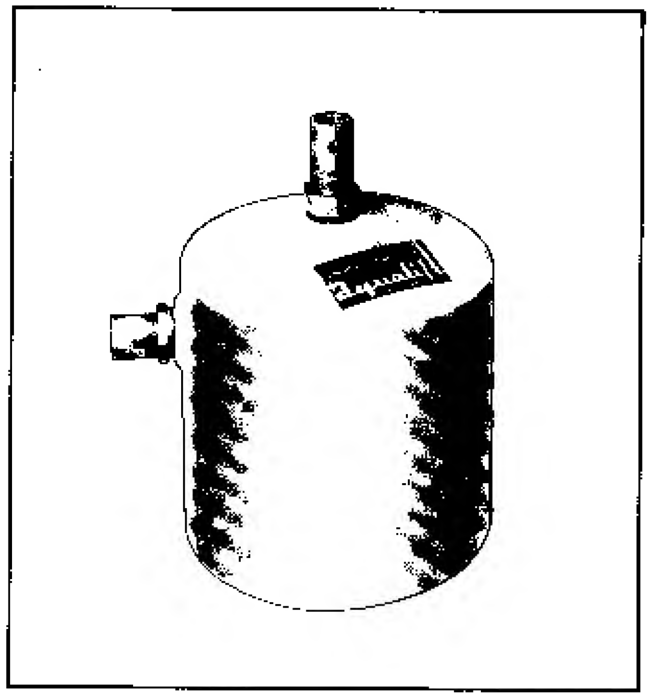


FIGURE 1-7. AQUALIFT MUFFLER

FUEL SYSTEM

FUEL TANKS

If the generator set and propulsion engines use the same fuel (gasoline or diesel), the generator set can usually be supplied from the main fuel tanks. See Figure 1-8.

WARNING Leakage of gasoline in or around the compartment is a definite hazard. The ventilation system should provide a constant flow of air to expel any accumulation of fuel vapor.

CAUTION Operating the electric set from a tee in the main fuel line can cause erratic operation. The set's fuel pump has neither the capacity nor the power to overcome the draw of propulsion engine fuel pump.

Position the tank fill and vent pipes so there is no chance of fuel or vapor escaping into the bilge. Run the vent and fill pipes from separate opening in the tank. If a flexible section of fill pipe is used, install a separate ground wire between the deck plate and fuel tank. Install the vent opening as far from any other hull opening as possible and with a gooseneck so water will not enter the pipe. Install a flame arrestor on the vent opening.

Figure 1-8 shows typical method of installing a second dip tube in the original fuel tank outlet. If the fuel tank outlet fitting is large enough to accommodate two dip tubes, the required fitting can be built by a machine shop.

FUEL LINES

1. Use seamless annealed fuel lines approved for marine installations.
2. Run fuel lines at the top level of tank to a point as close to the engine as possible to reduce danger of fuel siphoning from tank if the line should break.
3. Keep fuel lines away from hot engine or exhaust areas. This reduces chance of vapor lock.
4. Line must be long enough to prevent binding or stretching because of generator set movement.
5. Install an approved flexible non-metallic and non-organic fuel line between the solid fuel line and engine to absorb vibration.
6. Install lines so they are accessible and protected from injury.
7. Use nonferrous metal straps without sharp edges to secure the fuel lines.
8. If fuel line is metallic, ground with a suitable ground strap to the boat common bond conductor.

FUEL SYSTEM SIPHON PROTECTION

A carburetor float valve must not be trusted to hold back fuel if there is a gravity feed from the fuel tank. When the tank is installed above the engine level on gasoline units, a siphon break is necessary to prevent the fuel from emptying into the carburetor if the float valve is not closed. This also prevents the fuel from siphoning if the fuel line breaks at a point below the fuel level.

Siphon protection can be provided by an anti-siphon valve, or an electrically operated fuel stop valve at the tank withdrawal fitting (Figure 1-9). The electric stop valve is connected to the engine ignition circuit and allows fuel flow only during engine operation. To comply with USCG regulations, the valve must have manual override for emergency operation.

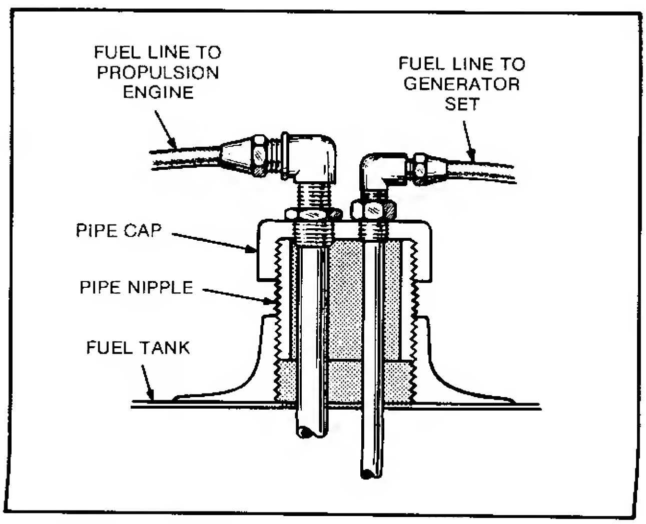


FIGURE 1-8. TWO FUEL LINES IN ONE TANK OUTLET

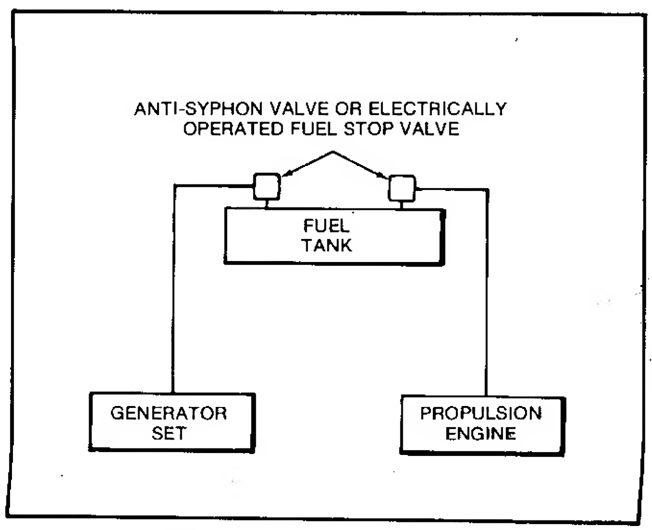


FIGURE 1-9. SIPHON PROTECTION

COOLING SYSTEM

Throughout this manual, floatation water drawn into the boat for engine cooling will be called sea water. Water recirculated through a closed system will be called captive water. Use of the term "sea water" does not necessarily imply that the water is salty. In fact, use of salt water in the engine block for cooling may result in severe corrosion problems. Units operating in a salt water environment should use either a keel type or heat exchanger type closed cooling system.

Three types of cooling in general use today are: direct (sea) water cooling (Figure 1-12); heat exchanger (captive water) cooling (Figure 1-10); and keel or skin (captive water) cooling (Figure 1-11).

DIRECT WATER COOLING

Direct Sea Water Cooling Systems use a rubber impeller pump to draw water directly from the lake or river, circulate the water through the engine's cooling system and out through the exhaust system. Water flow is controlled by a thermostat. A high water temperature cut-off switch protects the engine.

HEAT EXCHANGER COOLING

Heat Exchanger Cooling has two separate water systems, a captive water and a sea water system. The metal impeller pump circulates captive water through the engine's block, heat exchanger shell, water-cooled exhaust manifold and expansion tank.

The rubber impeller pump circulates sea water through the heat exchanger's core (cooling the captive water) and out through the water-cooled muffler.

KEEL COOLING

Keel Cooling, a captive water system, uses a metal impeller pump to circulate captive water through the engine's water jacket, exhaust manifold, expansion tank, and keel cooler tubing. The cooling tubes are attached to the vessel's hull, below the water line, so that sea water (floatation water) cools the captive water.

A rubber impeller pump circulates sea water for exhaust cooling.

WATER PUMP

Two types of pumps are in general use today, the metal impeller pump and the rubber impeller pump. Each has special advantages and disadvantages. See Figure 1-13.

CAUTION **Do not use the existing rubber impeller pump in the hot water side of the cooling system. Heat or soluble oil (in many rust inhibitors and antifreezes) will damage the impeller. Instead, connect the rubber impeller pump on the sea water side. Use a metal impeller pump (Onan #132-0110 or equal) in the captive water side.**

If the boat is used extensively in contaminated water where a strainer can't remove most of the dirt, install a centrifugal pump and filter below the water line as a sea water pump. Dirty water can still cause block plugging; therefore heat exchanger, keel cooling or skin cooling should be used under these conditions.

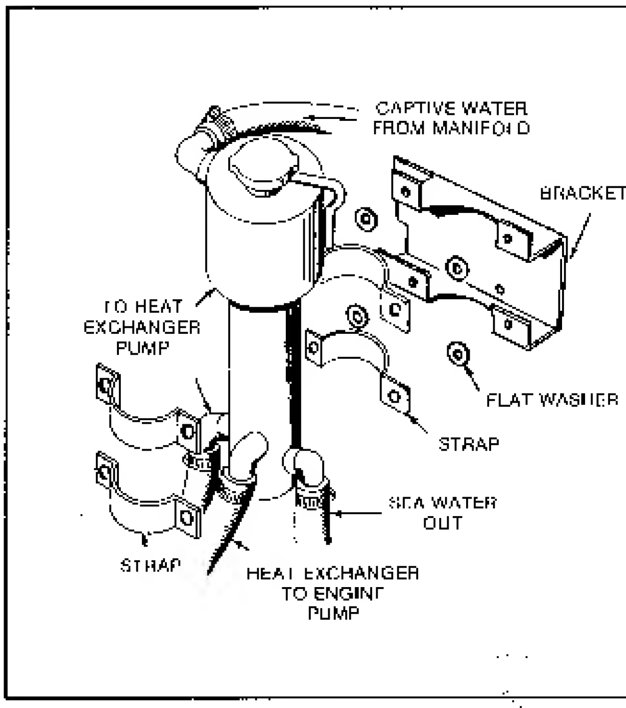


FIGURE 1-10. HEAT EXCHANGER COOLING SYSTEM

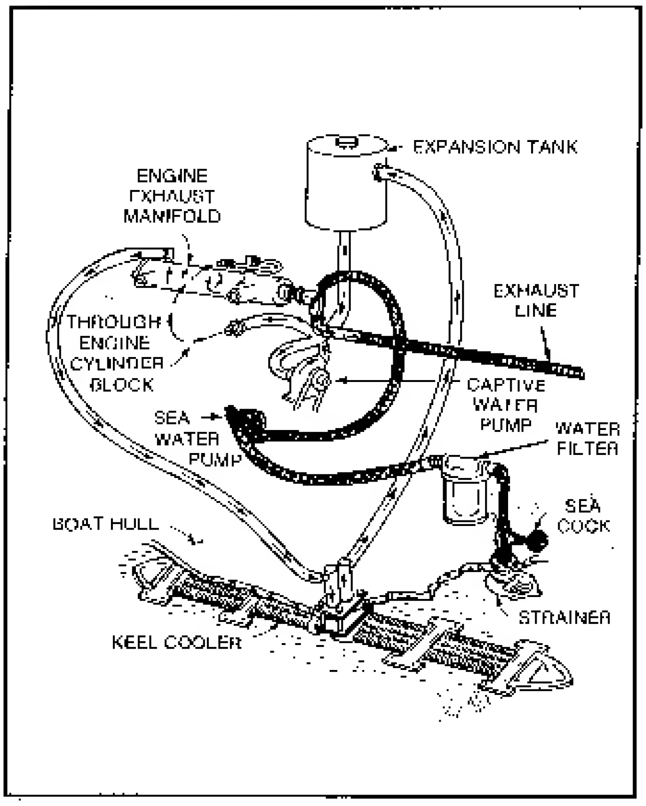


FIGURE 1-11. KEEL COOLING SYSTEM

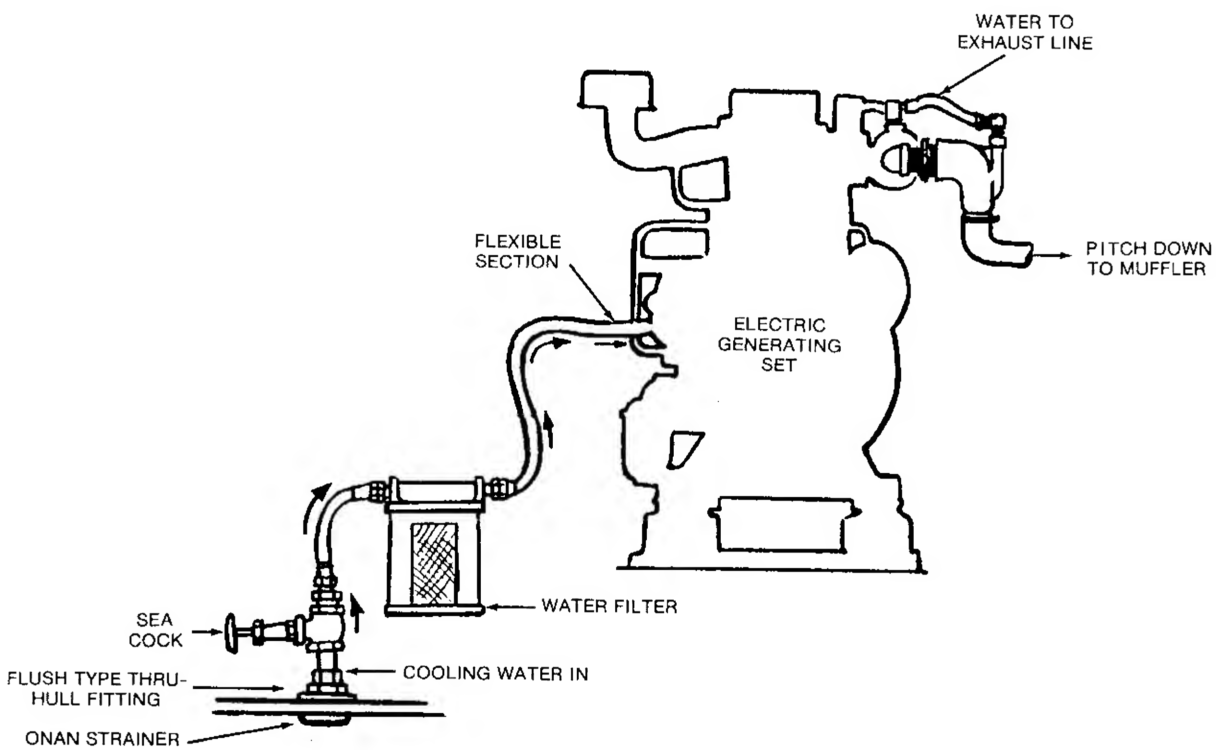


FIGURE 1-12. DIRECT COOLING SYSTEM

Use line of the proper size, following recommendations in Table 1-5. Increase the line size for runs over 5 feet (1.5 m) in length. One pipe size for each additional 10 feet (3 m) in length.

Water lines can be either copper tubing or flexible hose. In any case, use a section of flexible hose on the water inlet next to the generator set. Use another flexible section on the water outlet before it enters the exhaust line. This flexible section must be long enough to stop transfer of vibration.

Onan recommends using a water filter in the water line to protect the cooling system (Figure 1-12).

CAUTION **The flush-type thru-hull water inlet must have an opening at least as large as the water inlet line.**

Standard Onan marine sets are equipped for direct water cooling. Installation requires a through-hull fitting, sea cock and strainer.

TABLE 1-5. COOLING SYSTEM CONNECTING SIZES AND RECOMMENDED HOSE SIZES

ELECTRIC GENERATING SET	INLET SIZE (INCH)	OUTLET SIZE (INCH)	MINIMUM RECOMMENDED HOSE INSIDE DIAMETER IN INCHES(mm)
MDJA	1/2 OD hose adapter	Connected to exhaust elbow	1/2 (12.7)
MCCK, MJC, MDJE	1/2 OD hose adapter	3/8 (hose adapter furnished)	1/2 (12.7)
MDJC, MDJF	3/4 OD hose adapter	3/8 (hose adapter furnished)	3/4 (19)

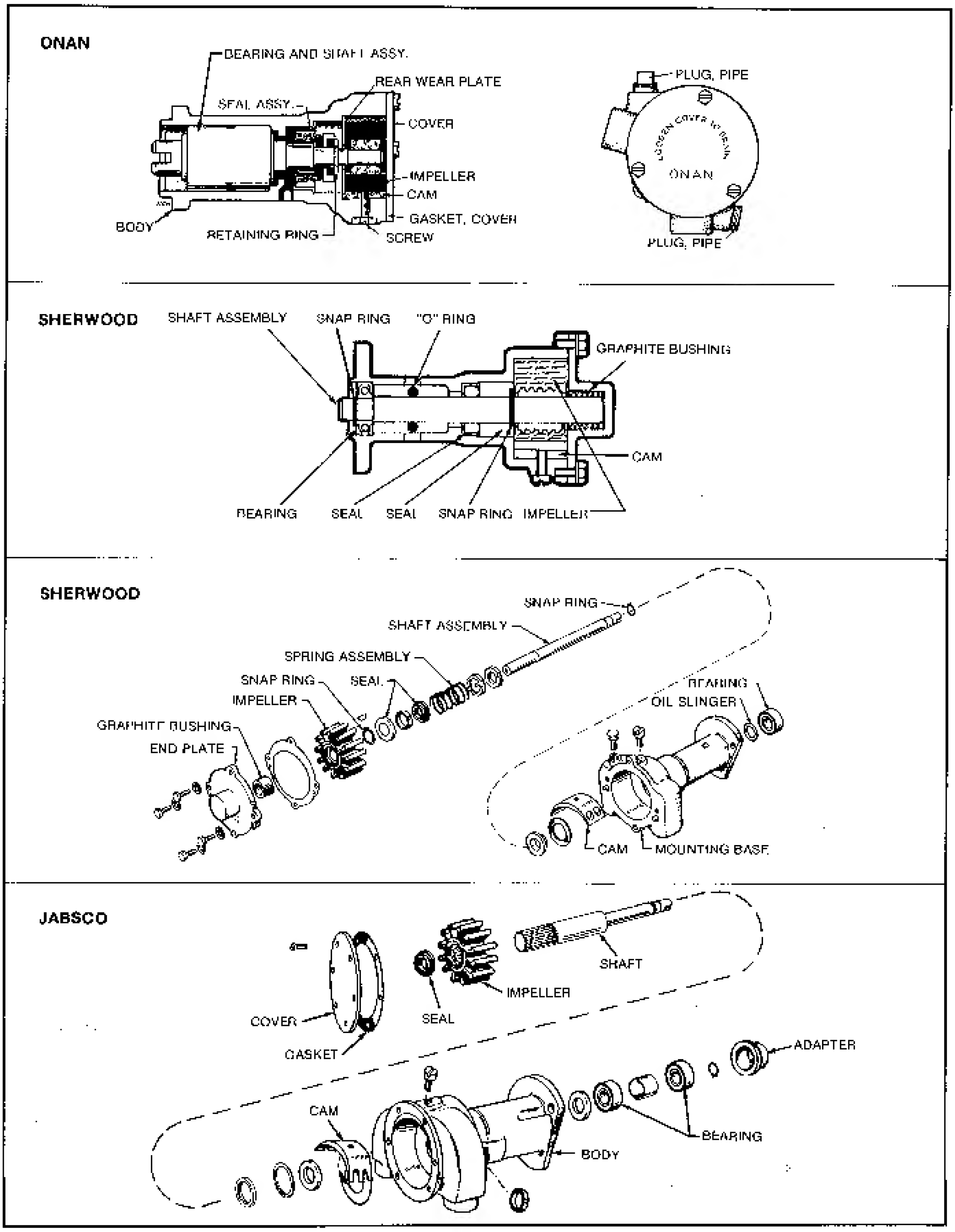


FIGURE 1-13. SEA WATER PUMPS

BATTERIES

Battery size is determined by the amount of power required to start the generating set. Position the battery where operation of the unit won't be impeded and air flow to and from the unit won't be restricted. Keep the battery well charged and the terminals clean and free of corrosion. See Table 1-6 for battery cable size and length. Refer to Table 1-7 for battery size recommendations. For further detailed information on the care and servicing of batteries, see *Miscellaneous Service Bulletin #2.*

POSITIVE CONNECTION

Connect the B+ cable to the start solenoid. When the solenoid is located inside the control box, run the control cable through the grommeted hole in the box clearing any metal parts of the control box or the generator.

CAUTION **Never disconnect the battery with either engine running and never crank both engines simultaneously.**

NEGATIVE CONNECTION

Connect the negative battery cable to the generator through-bolt using a shakeproof washer. Ground the set by connecting a separate cable to clean, bare metal on the frame. Use shakeproof washers between the cable lug and the frame. Use the same size cable for ground as for the negative battery terminal connection.

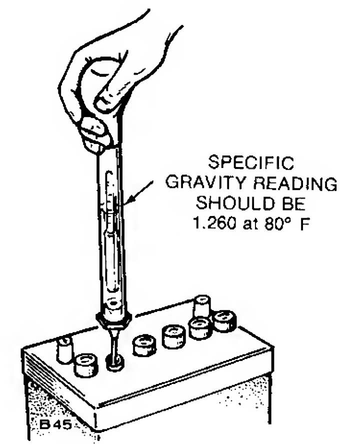


TABLE 1-6. BATTERY CABLE REQUIREMENTS FOR 12 VOLT ELECTRIC GENERATING SETS (MAX. LENGTH OF ONE CABLE)

CABLE SIZE	2	1	0	00	000	0000
MJC MDJC MCCK, MDJA MDJE, MDJF	4 ft.	5 ft.	7 ft.	9 ft.	11 ft.	14 ft.

TABLE 1-7. ONAN MARINE BATTERY RECOMMENDATIONS

GENERATOR SET SERIES	AMBIENT TEMP. RANGE	BATTERY SPECIFICATIONS					
		QTY. REQ'D	VOLTAGE	†BCI GROUP SIZE	CAPACITY *COLD CRANKING AMPS @0°F (-18°C)	CAPACITY #*APPROX. AMP-HR (kC)	ONAN PART NO.
MCCK Spec "H"	Entire Temp. range	1	12	60	360	70(252)	416-0365
MCCK Prior to Spec "H'	Entire Temp. range	2	6	1	450	105(378)	416-0457
MDJA MDJE	32° F (0° C) and warmer	2	6	1	450	105(378)	416-0457
	0°F(-18°C) and warmer	2	6	2H	565	135(486)	416-0363
MDJC MDJF	32°F(0°C) and warmer	2	6	2H	565	135(486)	416-0363
	0°F(-18°C) and warmer	2	6	5D	800	190(684)	416-0437
MJC	32° F (0° C) and warmer	1	12	60	360	70(252)	416-0365
	0°F(-18°C) and warmer	2	6	1	450	105(378)	416-0457

† - BCI is abbreviation for Battery Council International
* - Minimum recommended Battery Capacities and Ratings
# - Specification for Reference Only (No longer included in the SAE Battery Standard)

SUMMARY

PRACTICE SAFETY

Your last responsibility in the installation procedure of any marine electric generator set is to advise the owner/operator that proper maintenance is one assurance of continued safe and efficient performance of any gasoline or diesel fueled engine. The health and safety of their passengers and themselves depends upon thorough periodic inspections and repair when necessary. All repairs should be made by qualified electrical or mechanical service personnel.

NOTES

SECTION 2
OPERATION

- **Introduction**
- **Fuel and Oil Recommendations**
- **Periodic Service Guide Gasoline Engine Generator Sets**
- **Periodic Service Guide Diesel Engine Generator Sets**
- **Starting Methods**
- **Summary**

The theory of operation of gasoline and diesel engines is basically the same regardless of whether it is a 1, 2 or 4 cylinder engine. Onan uses a water cooled engine on all Marine generator sets. The engines are 4 stroke, internal combustion 4 cycle and naturally aspirated. The same is true for Onan generators whether inherently or voltage regulated. They all have the same basic parts for voltage generation: a magnetic field, conducting wire and movement or rotation. The controls do just exactly what the title says they do, they control. Some of the things they control are operating temperature, oil pressure, battery charging and ignition. All Onan generators are designed to give reliable electrical power if properly maintained to Onan specifications. In this section we hope to give the student a general understanding of the principals of operation for gasoline engines and the significant differences between gasoline and diesel engine operation. The same is true for generators whether inherently regulated or statically excited. No references to any particular models are intended, but a general description as applies to all Onan marine units currently in use in the field today.

FUEL AND OIL RECOMMENDATIONS

LUBRICATING OIL SELECTION

Lubricating oils for spark-ignited and diesel engines are made in a variety of service classifications, each in several viscosities. Selection of an oil for a particular engine, considering its fuel and operating conditions, is based on the classification and SAE viscosity grade.

Oil Classification

The requirements of an oil depend on the kind of engine, the operating conditions, and the fuel. A classification system, jointly developed by the American Petroleum Institute (API), the Society of Automotive Engineers (SAE), and the American Society for Testing and Materials (ASTM) is used to identify the classifications for engine service and operation conditions. The newest classification—SE—has been added to cover oils with very high resistance to oil oxidation (oil thickening) caused by high oil temperatures.

Oil Viscosity

Viscosity is a measurement of resistance to flow. For oil, this resistance is affected by temperature. Multiple grade oils are made to provide starting capability when the oil is cold and also to provide engine protection at higher operating temperatures. Viscosity identification is by the SAE grade number.

Gasoline Engines Only

Use oil with the API (American Petroleum Institute) designation SE or SE/CC. Refer to oil chart Figure 2-1 for recommended viscosity according to temperature.

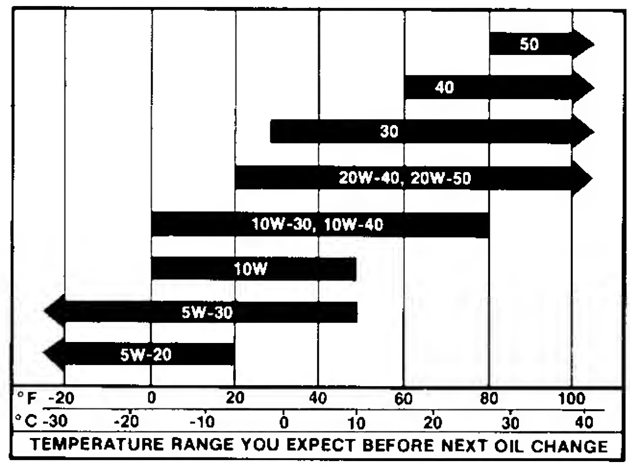
Oil consumption may be higher with a multigrade oil than with a single-grade oil if both oils have comparable viscosities at 210° F (99° C). Single grade oils are generally more desirable unless anticipating a wide range of temperatures.

Diesel Engines Only

Use an oil with the API designation CD/SE. However, to reduce oil consumption to a normal level in the shortest time possible on a new or rebuilt engine, use CC/SE oil for the first fill only (50 hours). Then use the recommended oil only. Select the correct SAE viscosity grade oil by referring to Figure 2-1.

Multigrade oils are recommended for temperatures of 32° F (0° C) and below, but they are not recommended for temperatures above 32° F. On Onan J-series water-cooled diesel engines, SAE 15W-40 or 20W-40 oils may be used in an ambient temperature range of 15° F (-10° C) through 90° F (32° C).

GASOLINE ENGINES ONLY



J-SERIES DIESEL ENGINES ONLY

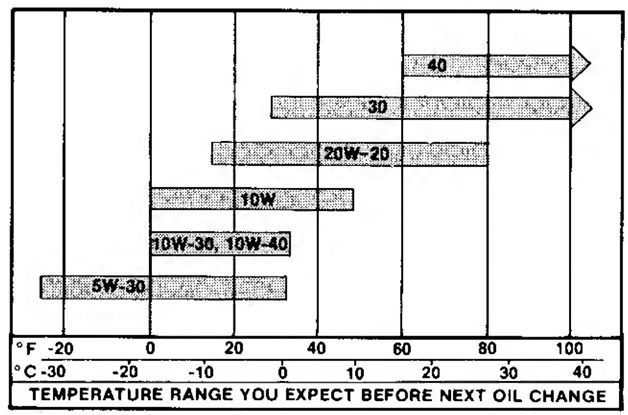


FIGURE 2-1. RECOMMENDED OIL VISCOSITIES

GASOLINE FUEL

Leaded Vs Nonleaded: Onan built engines operating on nonleaded gasoline run better, cleaner, and longer with less maintenance than if using leaded gasoline. We find that using nonleaded gasoline in preference to leaded gasoline helps reduce the following problems:

- Burned Valves
- Sticking Valves
- Spark Plug Fouling
- Piston Wear
- Ring Wear
- Cylinder Wall Wear
- Exhaust System Corrosion

For new Onan engines, most satisfactory results are expected through use of nonleaded gasoline. Use of

leaded gasoline in new or old Onan engines will usually cause more wear and require more maintenance. If changing from leaded gasoline to nonleaded, the engine head must be taken off and all lead deposits removed from the engine.

CAUTION If lead deposits are not removed from engine before switching from leaded to nonleaded gasoline, preignition would occur causing severe damage to the engine.

AIR CLEANER AND FLAME ARRESTORS

Properly serviced air cleaners and flame arrestors help ensure long engine life. Air cleaners remove abrasive dirt material from the air before it enters the engine. This increases operating efficiency and fuel economy and reduces engine wear. Restriction of intake air results in over-rich fuel mixture in either gasoline or diesel engines. Refer to individual operators manual for further information on your specific Onan engine. See Figure 2-2.

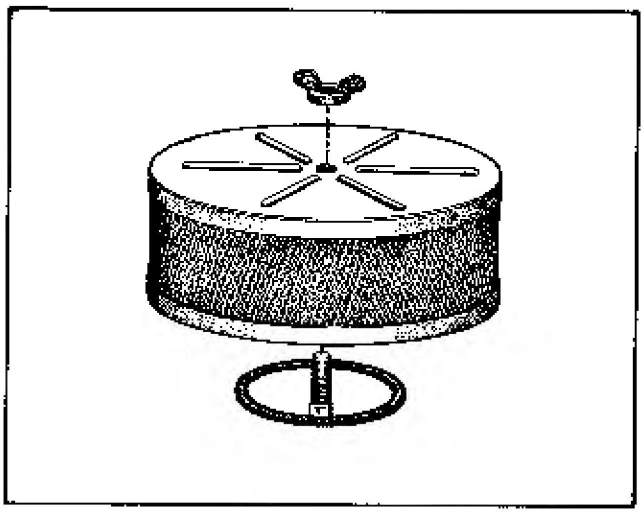


FIGURE 2-2. FLAME ARRESTOR

DIESEL FUELS

The selection of diesel fuel should be made on the basis of overall performance as well as economy. Diesel fuel serves two main purposes.

1. Supplies energy for the work done by the engine.
2. Lubricates all components in the diesel fuel system such as pumps, nozzles, etc.

Recommended Fuel

Use ASTM 2-D or 1-D fuel with a minimum Cetane number of 45 . Number 2 diesel fuel gives the best economy for most operating conditions; however, use ASTM 1-D fuel during the following conditions:

1. When ambient temperatures are below 32°F (0°C);
2. During long periods of light engine load; or no load.

NOTE: Fuels with Cetane numbers higher than 45 may be needed in higher altitudes or when extremely low ambient temperatures are encountered to prevent misfires.

Use low sulfur content fuel having a pour point (ability to filter) of at least 10°F (6°C) below the lowest expected temperature. Keep the fuel clean and protected from adverse weather. Leave some room for expansion when filling the fuel tank.

FUEL FILTERS

Fuel filters are required for protection of the fuel injection system even though good fuel handling practices are followed. It is absolutely necessary to use filters capable of removing micron-size particles from the fuel. Two-stage filtration is supplied with all Onan diesels. See Figure 2-3.

The fuel transfer pump pulls fuel directly from the storage tank. A metal sediment bowl traps water and most sediment particles. If continuing amounts of water and sediment are seen at the supply outlet, however, install a filter and water trap at this point.

Fuel is pumped through two filters before it reaches the injection pump. Average pore size of the second filter is .0005 smaller than the first filter. This means most particles escaping the first filter are trapped in the second filter.

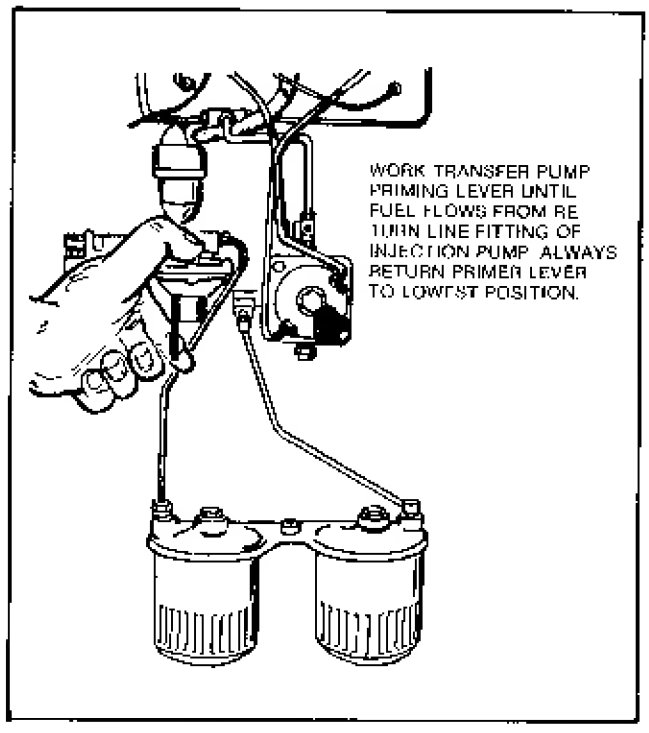


FIGURE 2-3. BLEEDING THE FUEL SYSTEM

PERIODIC SERVICE GUIDE FOR GASOLINE ENGINE GENERATOR SETS

SERVICE THESE ITEMS	AFTER EACH CYCLE OF INDICATED HOURS					
	8	50	100	200	500	1000
Inspect Marine Set	x1					
Check Fuel Supply	x2					
Check Oil Level	x					
Check Cooling System		x3				
Check Flame Arrestor		x6				
Inspect Exhaust System		x				
Check Spark Plug			x4			
Check Governor Linkage			x5			
Change Crankcase Oil			x5			
Check Battery Water Level		x				
Check Brushes				x		
Inspect Breaker Points				x		
Clean Crankcase Breather				x		
Clean Commutator and Collector Rings				x		
Clean Carburetor					x	
Remove Carbon & Lead Deposits					x	
Check Valve Clearance					x	
Clean Generator						x
Remove and Clean Oil Base						x
Grind Valves (If Required)						x
Replace Generator Brushes	As Required					

x1 - With set running, visually and audibly check exhaust system for leaks.

x2 - Check fuel system for leaks or damage.

x3 - Check pump pulley set screws and belts. Replace antifreeze annually in captive system.

x4 - Replace at 250 hours.

x5 - Perform more often in extremely dusty conditions.

x6 - Inspect for physical damage. Wash in suitable solvent.

Use this periodic service guide as a check list for important service requirements of all Onan marine generating sets. Strict observance of the time intervals and procedures in this chart promote long life for the unit and low service cost. Equating hours to miles makes the service intervals more realistic. On an 1800 rpm engine, one hour running time is equal to 40 miles (64 km) driven in an automobile. Keep the unit clean. Cleanliness of the generating set and the compartment directly affects the total operating efficiency of the unit. Blow out the unit and the compartment with clean, dry, compressed air. All time intervals are based on favorable operating conditions. More frequent intervals are necessary under adverse operating conditions. Refer to model operator's manual for detailed information on recommended service intervals.

PERIODIC SERVICE GUIDE FOR DIESEL ENGINE GENERATOR SETS

SERVICE THESE ITEMS	AFTER EACH CYCLE OF INDICATED HOURS 8	50	100	200	600	3000
Inspect Marine Set	x1					
Check Fuel	x					
Check Oil Level	x					
Check Cooling System		x3				
Check Flame Arrestor		x5				
Clean Governor Linkage		x4				
Change Crankcase Oil			x4			
Drain Fuel Condensation Traps			x			
Check Battery Electrolyte Level		x				
Replace Oil Filter (If Used)				x		
Empty Fuel Sediment Bowl				x		
Check Slip Rings and Commutator				x		
Check Brushes				x		
Replace Primary Fuel Filter					x	
Check Valve Clearances					x	
Replace Secondary Fuel Filter						x
Clean Generator						x
Inspect Valves, Grind If Necessary						x

x1 - With set running, visually and audibly check exhaust system for leaks.

x2 - Check fuel system for leaks or damage.

x3 - Check pump pulley set screws and belts. Replace antifreeze annually in captive system.

x4 - Perform more often in extremely dusty conditions.

x5 - Inspect for physical damage. Wash in suitable solvent.

The differences between the service items and the time intervals involved between gasoline and diesel engines is due mainly to precise fuel metering, absence of lead deposits and design differences. Examples would be fuel filters and valves in diesel engines which last almost twice as long on the average as similar parts in a gasoline engine. In some casos depending on the part involved, the service time interval for a gasoline engine part might be the same as a diesel part performing a similar function. Examples would be changing of oil, checking batteries or checking generator brushes. Refer to model operator's manual for more detailed information on recommended service intervals.

STARTING METHODS

The electrical starting system for engine-driven generator equipment is the most commonly accepted system. Some advantages of electric starting are: reliability, low cost, easy maintenance, and compatibility with other system controls. The main requirement of a good starting system is that it will crank the engine (gasoline or diesel) fast enough and at high enough voltage for other electrical systems. Most of today's electric starting systems require a battery for cranking power. With the use of built-in trickle charging systems or a separate battery charger; keeping the battery charged and in good condition should be standard procedure.

INITIAL START

Check the engine to make sure it has been filled with oil and fuel. Fill cooling system and prime the water pump. If engine fails to start at first attempt, inhibitor oil used at the factory may have fouled the spark plugs—remove, clean in a suitable solvent, dry thoroughly and reinstall. *Heavy exhaust smoke when the engine is first started is normal,* and is caused by the inhibitor oil.

On diesel engines be sure fuel system is air-free. If not, bleed the air from the fuel system as described in the *Operation* section of your Operator's Manual.

APPLYING LOAD

Allow set to warm up before connecting a heavy load and keep the load within nameplate rating. Continuous generator overloading may cause high operating temperatures that can damage the generator or engine.

Extremes in starting temperatures may require additional preheating. If engine fails to start quickly, rest engine several seconds and repeat starting sequence applying preheat for a longer interval.

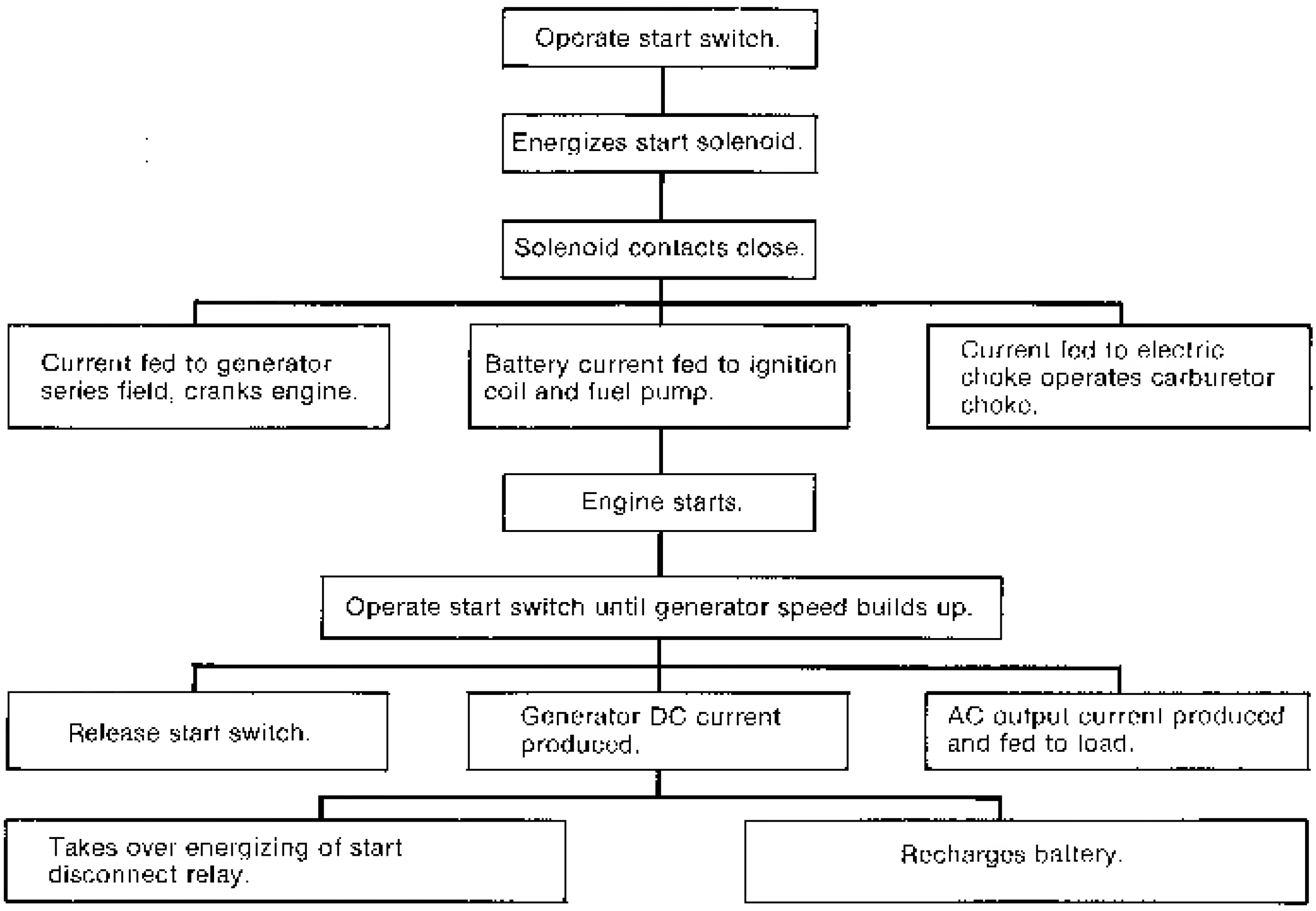
CAUTION **Do not apply overvoltage to the starting circuit at any time. Overvoltage will destroy the glow plugs and air heater in two to three seconds. If it becomes necessary to use an additional source of power to start the unit—use battery of the same voltage connected in parallel.**

IMPORTANT: Never start or run battery charging sets unless the battery is connected. Be sure the set-battery switch is closed and fuses are good.

STARTING SEQUENCE

1. Operator pushes START button, or set is started by remote control.
2. Start solenoid energizes.
3. Battery current flows to
   a) series field for cranking.
   b) STOP relay, completing ignition circuit.
4. Engine cranks.
5. Ignition coil fires spark plugs when breaker points open.
6. Engine starts.
7. Operator releases START button.
8. Start disconnect relay energizes.
9. Engine continues running.

EXCITER CRANKING SEQUENCE OF OPERATION
(GASOLINE MCCK ONLY PRIOR SPEC "H")



SUMMARY

When the Marine Electric Generating Set is correctly serviced and maintained, it will provide many hours of safe efficient operation. Service and maintenance includes performing preventive maintenance items at the correct time intervals shown in each operator's manual. All items necessary to prepare the generating set to start, run and test should be checked frequently. Items to be checked are things such as:

- Oil in crankcase
- Extra oil for filter
- Battery connections clean and tight
- Fuel lines tight
- Safe and proper installation
- Engine properly timed
- Rated voltage being produced
- Governor set for correct RPM

Remember, a clean engine looks and runs better than one which is not maintained. This extra care pays off in lower service costs and longer running life, increased performance and fuel economy.

This also enables the skipper to spend more time on the deck, out at sea and less time below deck at the pier.

Happy boating!

Notes

SECTION 3
ENGINE THEORY AND ADJUSTMENT
DIESEL AND GASOLINE

- **Introduction**
- **Basic Differences - Gasoline and Diesel Engines**
- **Onan Diesel Starting Guide**
- **Diesel Fuel Systems**
- **Adjustments (Diesel Powered Units)**
- **Troubleshooting Guide for Diesel Engines**
- **Adjustments (Gasoline Powered Units)**
- **Troubleshooting Guide for Gasoline Engines**
- **Summary**

The principles of operation of a gasoline or diesel engine are basically the same except for the fuel system components and the ignition system. Valves are sometimes referred to as the heart of an engine and the combustion process is called the brain of the engine. In between, the ignition system might be referred to as the pulse of the engine. All three systems must work together for the engine to do any work. If a gasoline and diesel engine of equal size were placed side by side, many parts would bear striking similarities. The key difference between the two types of engines is what happens inside during operation. Improvements in design, strength, light metals, economy and thermal efficiency are all factors which contributed to the growing popularity of diesel engines in the last few years. Pollution control and economy are major areas of improvement in gasoline engines. Some of the basic differences between gasoline and diesel engines are in the following systems:

- FUEL SYSTEM
- COMPRESSION RATIO
- IGNITION SYSTEM
- TIMING
- OPERATION
- EFFICIENCY

In this section the student should gain an understanding as to the significant differences between a gasoline and diesel engine and also the how, when and why certain adjustments are made and what adjustments to make on both types of engines.

BASIC DIFFERENCES BETWEEN GASOLINE AND DIESEL ENGINES

In the following comparison chart we will illustrate some of the major differences between gasoline and diesel engine operation. The chart will also serve to indicate why gas or diesel operation might be better suited to a specific type of usage. The key differences are as follows:

COMPONENT	GASOLINE	DIESEL
Fuel System	A. Consists of Fuel Pump Filter and Carburetor. Fuel and Air Mixture to Intake Manifold. B. Fuel and Air Mixed Before entering Combustion Chamber. Air Fuel Ratio 15-1.	A. Consist of Transfer Pump, Filters, Injection Pump and Nozzle. Air Only to Intake Manifold B. Only Air Enters Combustion Chamber; Fuel is injected at specific time. Air Fuel Ratio is 18-1 at full load and 100-1 at no load.
Type of Fuel	Gasoline - Flammable Storage Problems - Higher Cost	Diesel Fuel - Not as Flammable - Usually less expensive
Compression Ratio	7 to 1	18 to 1
Ignition System	Battery or Magneto Spark Plugs, Relays, Wires, Condenser, Points.	Compression Ignition at 1000° or more when running. During cranking, compression ignition starts the Onan built units.
Timing	*A. 19° BTC on models 1800 rpm or slower *B. 25° BTC on models 3600 rpm or faster * - MAJ & MCCK Models	(Port Closing) 17° BTC MDJA 21° BTC MDJB Before Spec P 19° Later Models After Spec P 21° BTC MDJC Before Spec P 19° Later Models After Spec P 18° BTC MDJE 19° BTC MDJF
Efficiency	Some wasted or unburned fuel - Less BTU's per gallon.	Good thermal efficiency. More BTU's per gallon converted to useful energy and power.
Operation	Faster Starting, Higher Operating Cost - Shorter Life Span.	A. Slower starting, need glow plugs for preheat, also air heaters. B. Nominal Outside Air Temperature - Very Important. C. Dirt and Air must be kept out of fuel system. D. Longer Life Span.

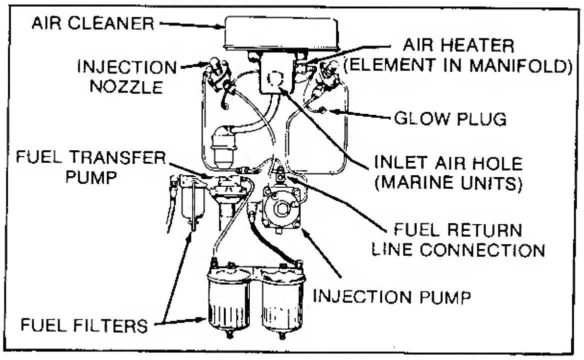
ONAN DIESEL STARTING GUIDE

IMPORTANT!

KEEP ENTIRE FUEL SYSTEM CLEAN AND FREE FROM WATER
- DIESEL INJECTION PUMPS WILL FAIL IF SYSTEM CLEANLINESS IS NEGLECTED

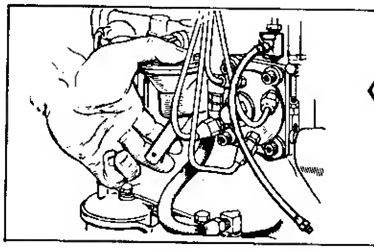
INJECTION PUMPS AND NOZZLES ARE NOT FIELD REPAIRABLE
- WHEN TROUBLESHOOTING, CHECK ALL OTHER COMPONENTS FIRST

WARNING **DO NOT USE ETHER STARTING AIDS! ETHER IS EXTREMELY EXPLOSIVE AND MAY CAUSE SERIOUS PERSONAL INJURY. ENGINE DAMAGE IS ALSO LIKELY.**



BEFORE STARTING:

CHECK FUEL SUPPLY. BE SURE SHUTOFF VALVES ARE OPEN.



PRIME FUEL SYSTEM IF: FUEL FILTERS WERE DRAINED OR CHANGED, SYSTEM WAS JUST INSTALLED, FUEL TANK RAN DRY.

TO PRIME PUMP. MOVE PRIMING LEVER UP AND DOWN UNTIL FUEL FLOWS STEADILY FROM RETURN LINE (DISCONNECTED).

PREHEAT

PREHEAT COLD ENGINE: PUSH PREHEAT SWITCH AND HOLD —
- **30 SECONDS IF ABOVE 55°F (13°C);**
- **60 SECONDS IF BELOW 55°F (13°C).**

TO START:

PREHEAT — **RELEASE PREHEAT**

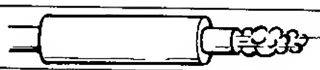
START / STOP — **ENGAGE START SWITCH**

LIMIT CRANKING TO 15 TO 20 SECONDS TO CONSERVE BATTERY. ALLOW 1 MINUTE BEFORE RE-CRANKING.

IF ENGINE DOES NOT START:

IF ENGINE FIRED, REPEAT ABOVE PROCEDURES, INCLUDING PREHEAT. IF IT STILL DOES NOT START, PROCEED AS FOLLOWS:

TEMPERATURES BELOW 32°F (0°C): **USE NUMBER 1 DIESEL FUEL. USE CORRECT VISCOSITY OIL. KEEP BATTERIES FULLY CHARGED. DO NOT USE ETHER STARTING AID.**



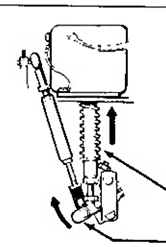
OBSERVE ENGINE EXHAUST "SIGNALS":

BLUE-WHITE EXHAUST SMOKE: ENGINE IS GETTING FUEL

1. **OBSERVE AIR HEATER THRU AIR INLET HOLE OR BY REMOVING AIR CLEANER.**
2. **ENGAGE PREHEAT.**
3. **IF HEATER ELEMENT DOES NOT GLOW RED WITHIN 30 SECONDS, CHECK AIR HEATER AND GLOW PLUG WIRING:**
   - **CONNECTIONS TIGHT?**
   - **FREE FROM CORROSION?**

LITTLE OR NO EXHAUST SMOKE: ENGINE IS NOT GETTING FUEL.
- **PRIME FUEL SYSTEM AS SHOWN ABOVE: OBSERVE FUEL FLOW FROM RETURN LINE**

FUEL FLOWS STEADILY



CHECK FUEL SOLENOID: SOLENOID ROD SHOULD PULL IN AND THROTTLE ARM FOLLOW (AS SHOWN) WHEN START SWITCH IS TURNED ON. IF NOT, CHECK FOR
- **BINDING LINKAGE**
- **LOOSE OR BROKEN WIRES**

LITTLE OR NO FUEL FLOW

CHECK FUEL SUPPLY SYSTEM:
- **FUEL TANK EMPTY?**
- **SHUTOFF VALVES CLOSED?**
- **FUEL LINES KINKED?**
- **LOOSE CONNECTIONS?**
- **CLOGGED FUEL FILTERS?**

IF ENGINE IS STILL NOT GETTING FUEL, CHECK TRANSFER PUMP:
1. **CRANK ENGINE AND OBSERVE FUEL FLOW FROM RETURN LINE.**
2. **IF FUEL DOES NOT SPURT OUT, PUMP MAY BE DEFECTIVE.**

IF ENGINE STILL DOES NOT START, CONTACT AUTHORIZED ONAN SERVICE REPRESENTATIVE

2-79 900-0217

DIESEL FUEL SYSTEMS

FUEL SYSTEM

The fuel system (Figure 3-1) consists of a metal sediment bowl, fuel transfer pump, primary filter, secondary filter, injection pump, injectors, and the connecting fuel lines.

The fuel system, located on the service side of the engine, uses a transfer pump to deliver fuel from the tank to a high pressure injection pump at about 12 to 14 psi (83-97 kPa) (5-6 psi on DJA [35-41 kPa]). The injection lines deliver fuel to the injectors at high pressure and act as fuel distributors to the injectors. The time interval between individual injectors is varied in the pump by engine speed. From the injection pump, metered fuel is forced through a delivery valve to the injector lines at about 1900 psi (13,110 kPa). When the cylinder air reaches about 1000°F (538°C) on the compression stroke, the injector sprays fuel into the hot compressed air where it ignites. The delivery valve in the injection pump and a pintle valve in the injector assists the precision timed injection of fuel into the cylinder.

FILTER SYSTEM

The sediment bowl has a fine mesh screen which blocks dirt and water entry into the transfer pump, Figure 3-2. The dirt and water remain in the sediment bowl which should be removed for cleaning as required. The primary and secondary fuel filters are replaceable spin-on units that clean the fuel of extremely fine particles before it goes to the injection pump.

These filters are mounted on a common casting which bolts to the oil fill tube. Positive filtration is assured because the engine won't run when either filter is loose or missing.

Average pore size of the second filter is .0005 (0.0127 mm) smaller than the first filter. This means most particles escaping the first filter are trapped in the second filter.

CAUTION A diesel engine cannot tolerate dirt in the fuel system. It is one of the major causes of diesel engine failure. A tiny piece of dirt in the injection system may stop your unit. When opening any part of the fuel system beyond the secondary fuel filter, place all parts in a pan of clean diesel fuel as they are removed. Before installing new or used parts, flush them thoroughly, and install while still wet.

FUEL TRANSFER PUMP

The fuel transfer pump (Figure 3-3) is a diaphragm and check valve type pump operated by a cam lobe on the engine camshaft. The pump cam follower has a wide surface to prevent wear as it rides on the camshaft lobe. The priming lever is manually operated to prime and bleed the system.

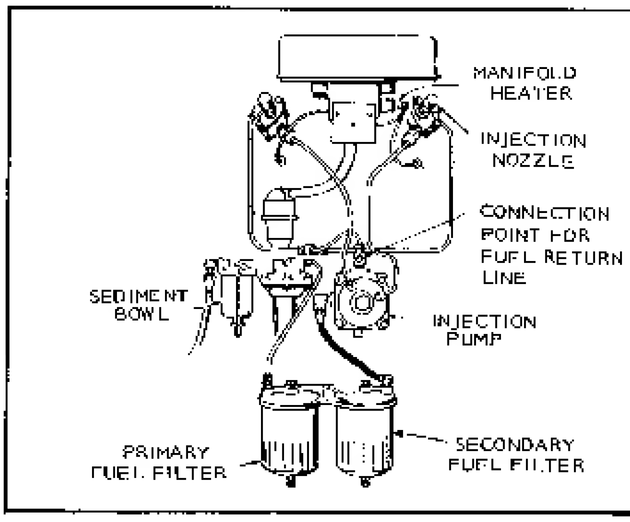


FIGURE 3-1. FUEL SYSTEM—LATEST MODELS

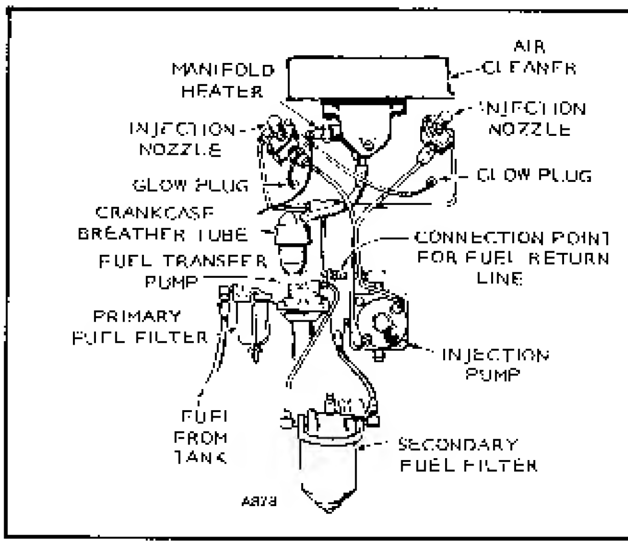


FIGURE 3-2. FUEL SYSTEM—OLDER MODELS

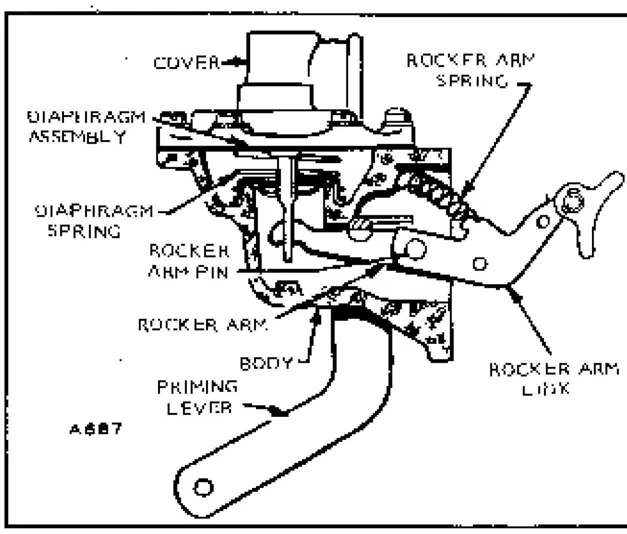


FIGURE 3-3. FUEL TRANSFER PUMP

The diaphrgam spring maintains required fuel pressure to the injection pump. Fuel pressure should be as follows when operating at 1800 rpm:

MDJA .... 5 to 6 psi
(34.5 to 41.4 kPa)
MDJC, MDJE, MDJF .... 12 to 14 psi
(83 to 97 kPa)

Fuel pump pressure may be checked by connecting a pressure gauge and tee at the fuel outlet. A vacuum gauge connected at the fuel inlet will show whether the pump has enough capacity to lift fuel about 6 feet (1.86 m). The fuel pump should produce 15 to 18 inches (25.4 to 43.4 mm) of vacuum at sea level.

INJECTION NOZZLES

Onan J series diesel engines use hydraulically-operated, non-throttling, pintle-type injection nozzles, Figure 3-4. They are factory adjusted to open at 1900 to 1950 psi (13,110 to 13,455 kPa). However, after several hundred hours of operation the nozzle pressure will decrease to about 1750 psi (12,075 kPa).

Refer to the throttling pintle type nozzle information at the end of this section for information regarding MDJE engines using Bryce/Kiki fuel systems.

Operating Principle

Nozzle operation is as follows:

1. High pressure fuel from the injection pump enters the fuel inlet stud and flows down drilled passages in the body of nozzle holder, Figure 3-5.
2. Fuel enters fuel duct and pressure chamber of nozzle assembly. When fuel pressure overcomes preset pressure of the adjusting spring, the pintle is forced upward off its seat and a fine mist of fuel is injected into the pre-combustion chamber where it atomizes and mixes with the hot compressed air.
3. If compression temperatures are high enough, the fuel-air mixture ignites. Injection continues until the spill port clears the top of the metering sleeve in the injection pump and dumps the high pressure fuel into the sump allowing the pressure spring to close the injector and cut off fuel injection to the cylinder.

CAUTION **Do not disturb the injector pressure adjusting screw; it cannot be reset without proper equipment.**

Excess fuel is returned to the tank after each injection cycle by a return line from the nozzle. A fuel return fitting combines the return fuel from the injectors with the flow-through fuel from the injection pump bleed valve. A return line connected at this point returns the combined fuel back to the fuel supply tank.

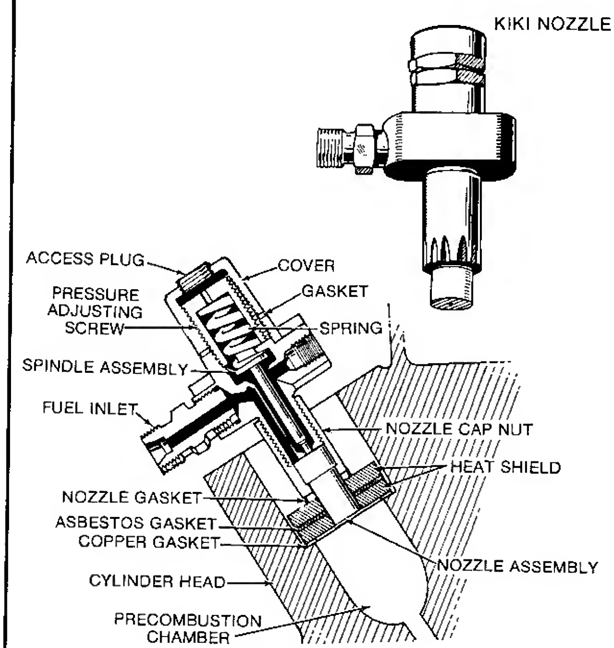
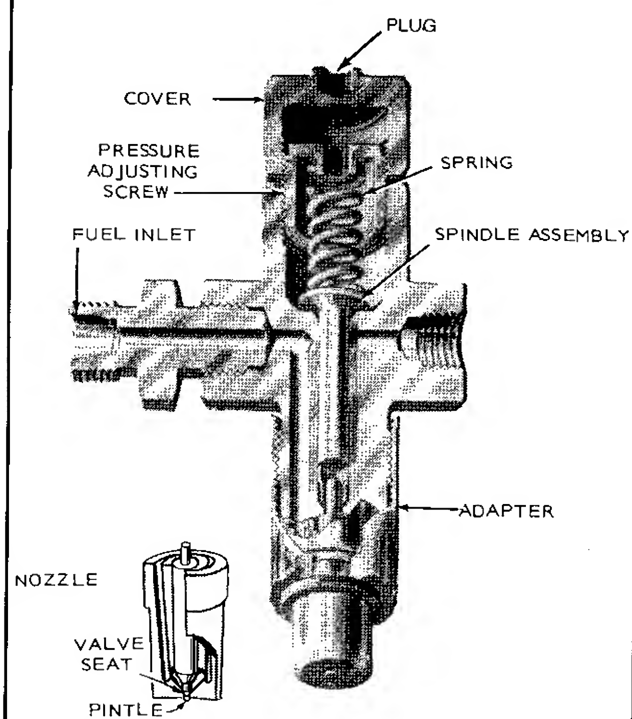


FIGURE 3-4. NOZZLE ASSEMBLY



CAUTION **Do not attempt to disassemble the nozzles or adjust nozzle pressure without the proper test equipment. A nozzle pressure tester is essential to do a satisfactory job.**

FIGURE 3-5. INJECTOR NOZZLE HOLDER

Nozzle Spray Pattern

If one cylinder is misfiring, its nozzle may be operating improperly. Faulty nozzles can be checked by loosening the high pressure line from the injection pump to each nozzle (one at a time).

A suspected nozzle can be checked in the field by removing it from the engine and reconnecting it to the high pressure line. The spray pattern (Figure 3-6) can be observed as the engine is cranked.

WARNING **Keep hands away from a spraying nozzle! The nozzle discharge pressure can penetrate the skin and may cause blood poisoning or a serious skin infection.**

A second method for determining a misfiring nozzle is to remove the exhaust manifold and run the engine under load. One can readily see by the exhaust which cylinder is not operating properly.

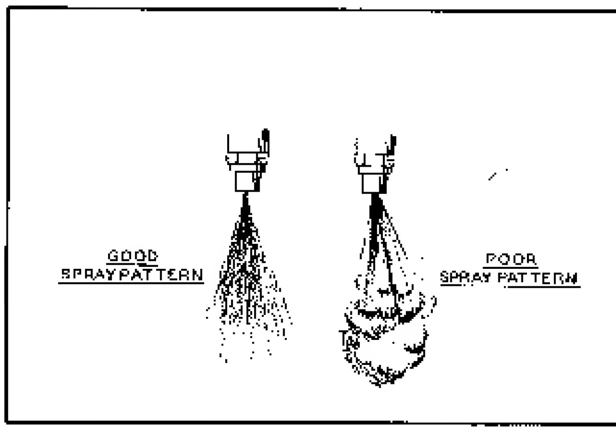


FIGURE 3-6. NOZZLE SPRAY PATTERN

Injection Nozzle Tester

Testing and adjustment can be performed only with a nozzle tester, Figure 3-7. Do not attempt to disassemble the nozzles or adjust nozzle pressure without the proper test equipment.

The cleaning procedure (Figure 3-8) is extremely important when disassembling injection equipment. Always rinse in clean fuel before reassembling.

Opening pressure, leakage and spray pattern can be checked using the tester. If any of the above malfunctions appear (except opening pressure), the nozzle valve and seat can be inspected with a magnifying glass for erosion, scoring, etc. If cleaning with solvent does not correct the malfunctions, a new nozzle tip will be required. The opening pressure can then be set and spray pattern checked.

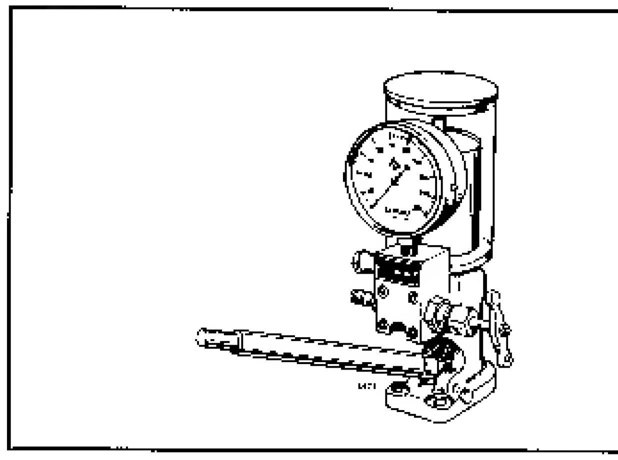


FIGURE 3-7. INJECTION NOZZLE TESTER

CAUTION **Never use hard or sharp tools, emery paper, grinding powder or abrasives of any kind or the nozzles may be damaged beyond use.**

Soak each nozzle in fuel to loosen dirt. Then clean the inside with a small strip of wood soaked in oil and the spray hole with a wood splinter. If necessary, clean the outer surfaces of the nozzle body with a brass brush but do not attempt to scrape carbon from the nozzle surfaces. This can severely damage the spray hole. Use a soft oil-soaked rag or mutton tallow and felt to clean the nozzle valve.

Nozzle cleaning kits are available from Onan Tool Catalog 900-0019.

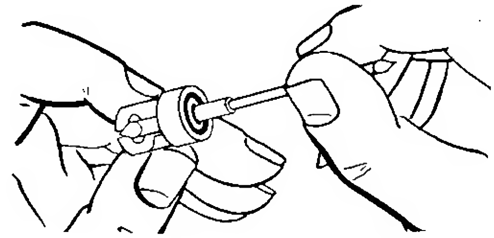
NOZZLE REPAIR

If cleaning will not eliminate a nozzle defect, replace the nozzle or take it to an authorized American Bosch service station. Do not attempt to replace parts of the nozzle except for nozzle and pintle assembly.

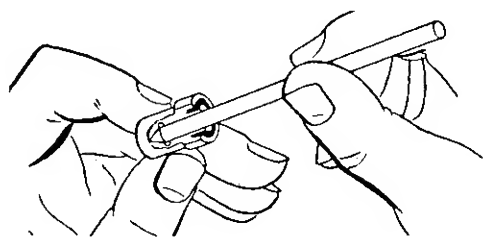
Assembly

Rinse both valve and nozzle thoroughly before assembly and coat with diesel fuel. The valve must be free in the nozzle. Lift it about 1/3 out of the body. It should slide back to its seat without aid when the assembly is held at a 45-degree angle. If necessary, work the valve into its body with clean mutton tallow.

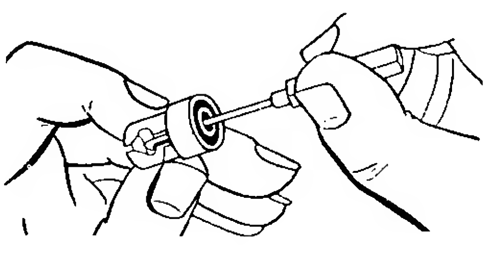
1. Clamp nozzle holder body in a vise.
2. Set valve in body and set nozzle over it.
3. Install nozzle cap nut loosely.
4. Place centering sleeve over nozzle for initial tightening. Then remove centering sleeve to prevent it from binding between nozzle and cap nut.
5. Adjust to specified torque.



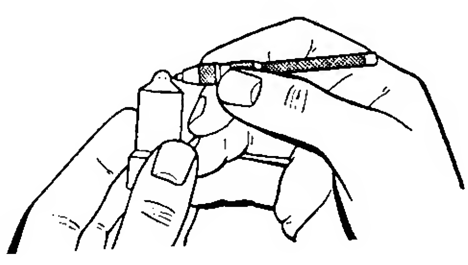
1. Use a brass type scraper tool to remove hard carbon deposits from nozzle body valve seat.



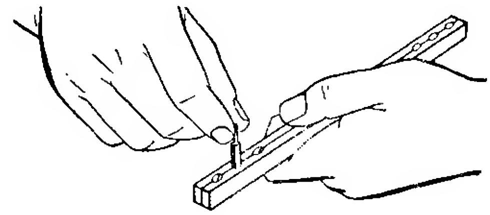
2. After scraping the carbon, polish the valve seat by using a round pointed stick dipped in tallow. Polishing should restore seat to its original finish unless it's scored.



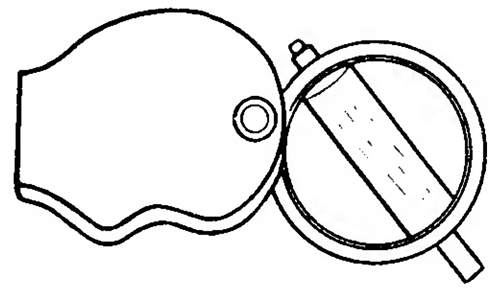
3. Use a special hooked type scraper to clean the nozzle pressure chamber gallery. The hooked end of scraper is inserted into the gallery and then carefully rotated.



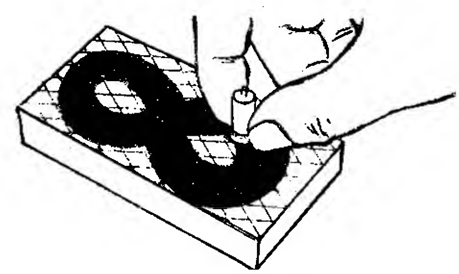
4. Small holes in tip of nozzle body can be cleaned with a fine wire slightly smaller than the size of the hole.



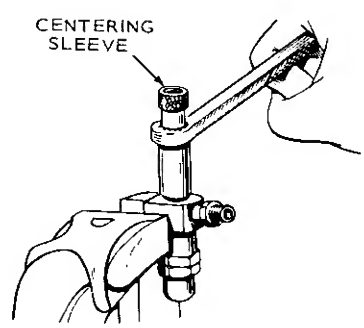
5. Clean nozzle valve and polish with tallow and a wooden polishing fixture. Take care to remove all traces of tallow when finished.



6. Examine nozzle valve and body with a magnifying glass. If erosion and scoring conditions are found, renew the valve and body.



7. Use a lapping plate and compound for flat lapping of nozzle parts which depend on a lapped surface for sealing. A figure "8" motion is used.



8. It is essential that the nozzle body is perfectly centered in the cap nut when reassembling nozzle. A centering sleeve, as shown, is used for this purpose.

FIGURE 3-8. NOZZLE CLEANING

NOZZLE INSTALLATION

Before installing the injection nozzles in the engine, thoroughly clean each mounting recess.

A dirty mounting surface could permit blow-by, causing nozzle failure and a resulting power loss.

1. Install a new heat shield to head gasket in cylinder head recess.
2. Install heat shield, a new nozzle gasket and nozzle adapter.
3. Insert nozzle assembly into recess. Do not strike tip against any hard surface.
4. Install nozzle flange and two cap screws. Tighten cap screws alternately to avoid cocking nozzle assembly. Tighten each to 20-21 foot-pounds (27-28 N•m).

FUEL SOLENOID

The fuel shutoff solenoid (Figure 3-9) is also referred to as a governor solenoid as it over-rides the governor during shutdown. The solenoid is mounted on the cylinder air housing bottom pan and controls the injection pump operating lever. When energized, the plunger pulls into the solenoid body. When de-energized, the solenoid spring forces the plunger out against the operating lever to hold it in the fuel shutoff position.

The solenoid has two coils. Both are energized for pulling the plunger up. When the plunger reaches the top, it opens a set of contacts, de-energizing the pull-in coil. The other coil holds the plunger up while the engine is running and de-energizes when the engine shuts down.

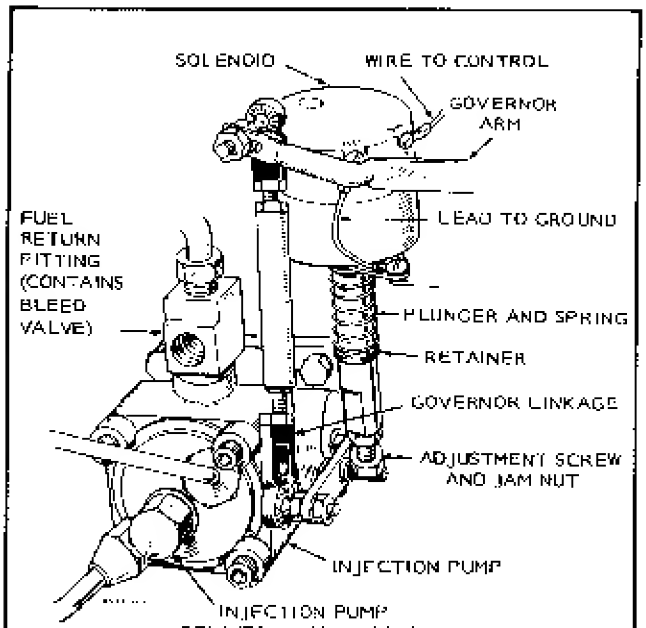


FIGURE 3-9. FUEL SHUTOFF SOLENOID

PREHEATING CIRCUIT

This 12 volt battery circuit consists partly of manifold heaters that heat the combustion air at the intake manifold and a glow plug in each cylinder that heats the precombustion chamber for engine starting, Figure 3-10. The manifold heater and glow plugs are wired in parallel and are controlled by a preheat switch on the control box.

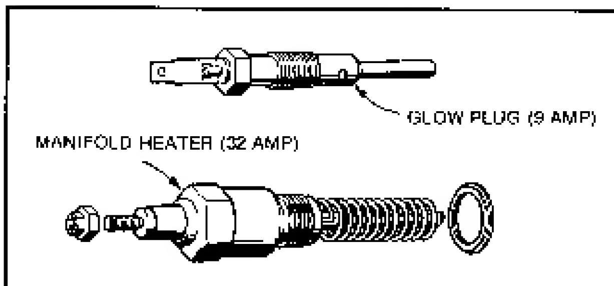


FIGURE 3-10. GLOW PLUG AND MANIFOLD HEATER

FUEL INJECTION PUMPS

Onan DJ series diesels are equipped with American Bosch fuel injection pumps. Single cylinder engines use the model PLB; the four cylinder engines use the model PSU pump. Until recently, the two cylinder diesel engines have been using a PSU pump. Now, the MDJE engines use either a Bryce or a Kiki fuel injection pump. For Bryce/Kiki pump information, turn to the back of this section. The fuel injection pumps are constant stroke, lapped plunger type and operated by the engine camshaft. They deliver an accurately measured quantity of fuel under high pressure to the injection nozzles.

A constant bleed-check valve is furnished with all PLB and PSU pumps. The bleed valve automatically bleeds off a restricted amount of fuel, fuel vapors, and small quantities of air to prevent air accumulation in the fuel sump area of the pumps. This valve should open at pressures between 0.9 and 3.0 psi (6.2 and 20.7 kPa).

CAUTION Replace injection pumps that troubleshooting procedures prove to be malfunctioning with new pumps. Do not attempt unauthorized repair procedures on the injection pumps.

Fuel injection pumps must pass stringent quality inspections and tests with precise settings and adjustments in order to meet Onan's performance and reliability requirements. Therefore, it must be clearly understood by the owners and by Onan servicemen that tampering or inept repair attempts can cause irrepairable damage to the pumps that will not be covered by the manufacturers warranties or exchange agreements. Contact an authorized American Bosch Service station or Distributor for expert repair service on the injection pumps.

The repair service should include cleaning, part replacement, static pressure tests for internal and external leaks, internal pump timing, and calibration and adjustment to the manufacturer's specifications.

PLB Injection Pump

The PLB injection pump (Figure 3-11) is used on the DJA Series engines. The cross-sectional view shows the internal parts and the operating lever and control shaft.

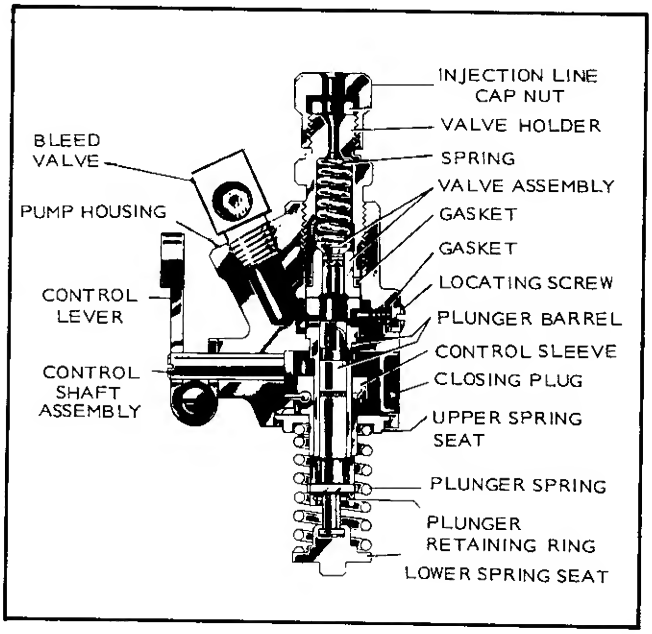


FIGURE 3-11. PLB INJECTION PUMP COMPONENTS

The pump consists of a housing, pump plunger and barrel, the plunger return spring with its seats, and the control sleeve and its operating shaft. The housing contains the fuel sump, delivery valve assembly, delivery valve holder, and the union nut for connection of the high pressure discharge tubing.

Operating Cycle

During operation, when the piston nears the end of each compression stroke, the plunger moves upward, closes its internal ports, and traps fuel that forces the delivery valve off its seat. Fuel flow is up through the delivery valve and spring to the high pressure line leading to the injector nozzle.

The plunger continues injection until the helix on the plunger (Figure 3-12) passes through the sleeve and spills fuel, dropping the pressure rapidly. Delivery valve action aids in dropping line pressure and keeps fuel from draining out of the line.

The amount of fuel delivered is controlled by the sleeve which rotates the plunger, thus changing the length of its effective pumping stroke. The distance the plunger travels is always the same because the cam lift never varies.

Injection timing on the one cylinder DJA Series engine with the PLB injection pump is at 17 degrees BTC.

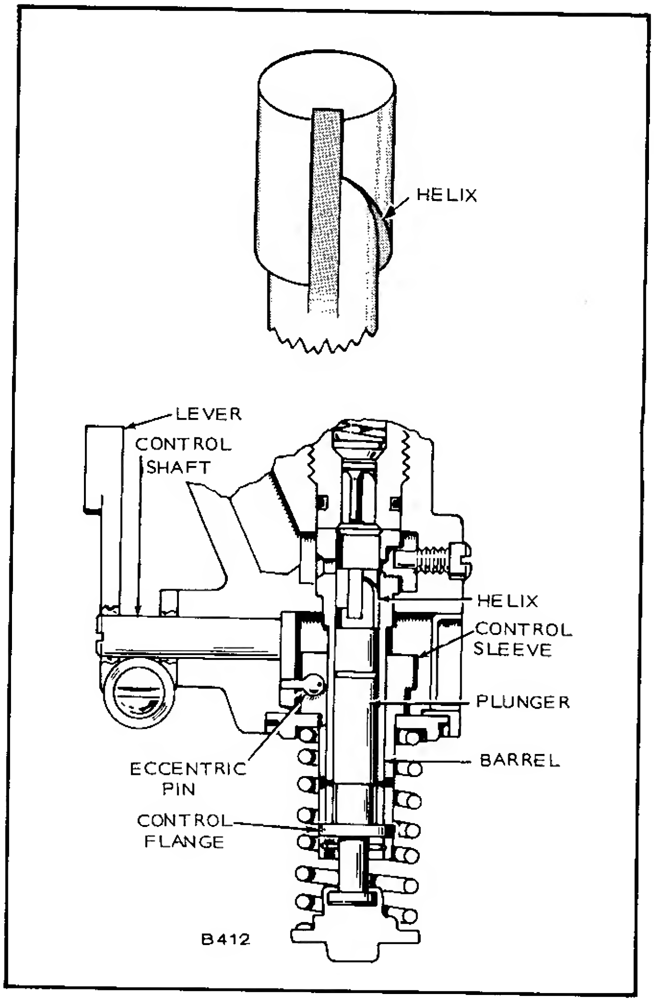


FIGURE 3-12. PLB PUMP

PLB PUMP OPERATION

The pumping action involves both the pumping and the metering principles, Figure 3-13.

Pumping Principle

A. Fuel enters the pump from the supply system through the inlet connection and fills the fuel sump which surrounds the barrel. With the plunger at the bottom of its stroke, fuel flows through ports in the barrel filling the space above the plunger, the vertical slot in the plunger and the cut-away area below the plunger helix.

B. As the plunger moves upward, the barrel ports are closed by the plunger.

C. As the plunger moves further upward, the fuel is discharged through the delivery valve into the high pressure line.

D. Delivery of fuel ceases when the plunger helix passes and opens the barrel spill port and the delivery valve returns to its seat. During the

remainder of the stroke, fuel is spilled back into the sump. This termination of fuel delivery controls the quantity of fuel delivered per stroke.

Metering Principle

Fuel metering includes long strokes for maximum delivery, shorter strokes for normal delivery, and non-effective pumping strokes with no delivery for engine shutdown.

The amount of fuel delivered is controlled by rotating the plunger, thus changing the length of its effective pumping stroke.

E. For maximum delivery, the effective part of the stroke is relatively long before the spill port opens.

F. For normal delivery, the effective part of the stroke is shorter before the spill port opens.

G. This view shows the plunger rotated to the OFF position so that the vertical slot on the plunger and the spill port are in line for no delivery even though the pump may continue to stroke, such as during a cranking condition with the fuel control lever at OFF.

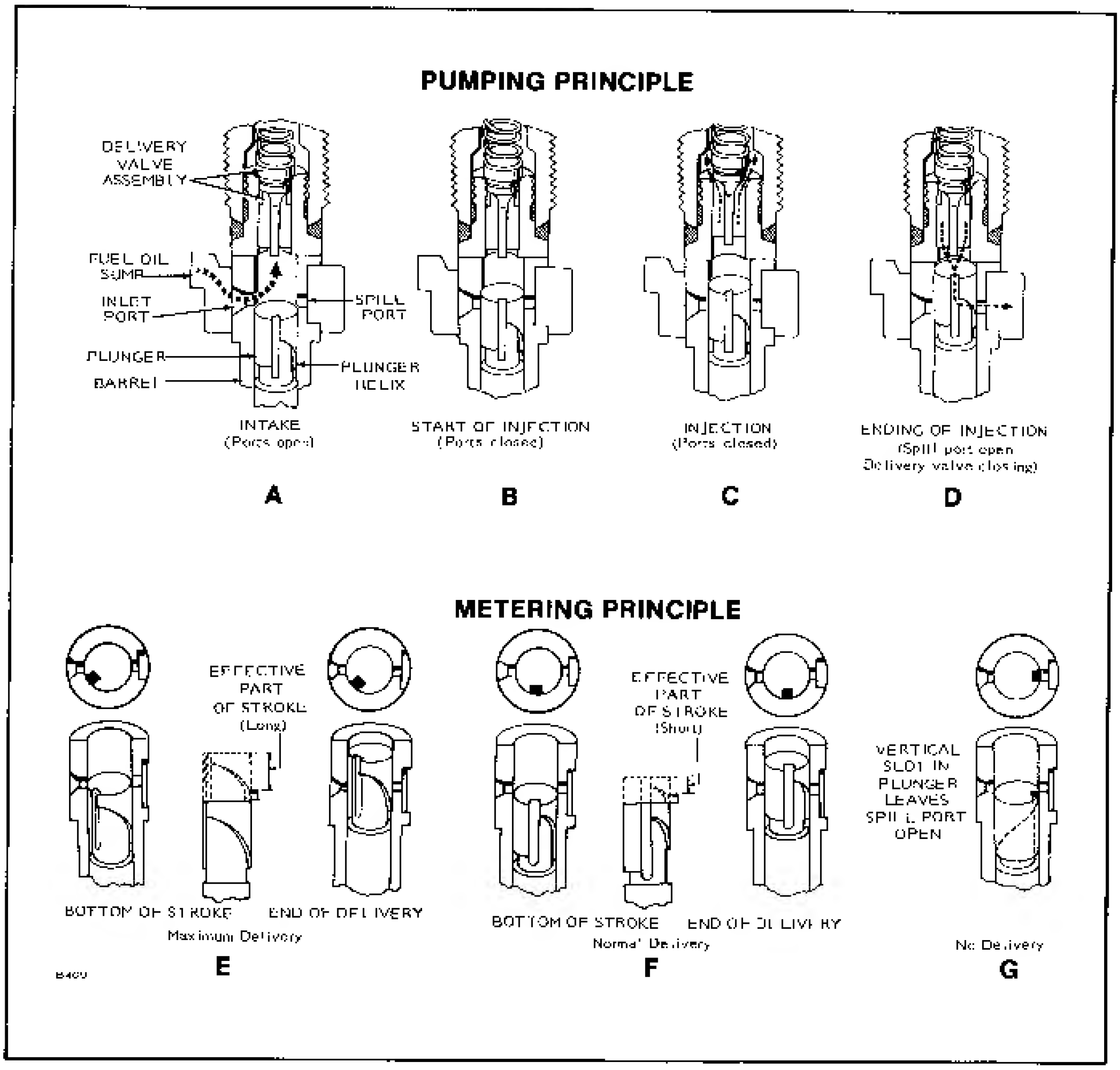


FIGURE 3-13. PLB INJECTION PUMP OPERATION (ALSO BRYCE AND KIKI)

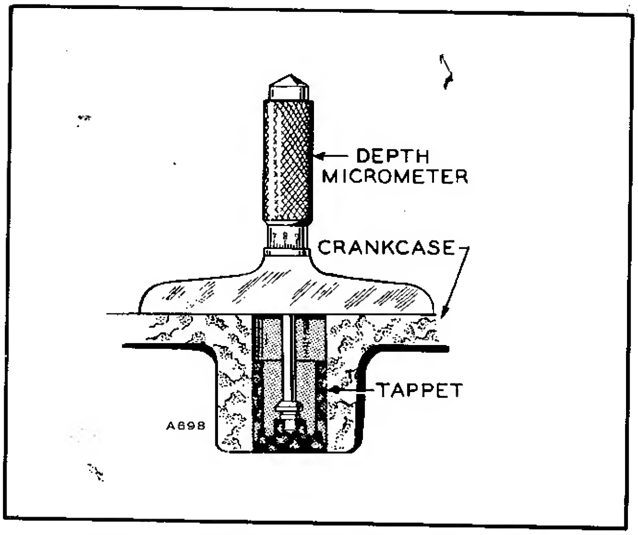


FIGURE 3-14. DEPTH MICROMETER MEASUREMENT

TIMING THE PLB PUMP (DJA)

Pump timing procedures determine the correct thickness of shims between pump and engine so port closing occurs at 17° BTC.

The most accurate method of injection pump timing is with a depth micrometer (Method 1). However, if a depth micrometer isn't available, time it by *Flowing the Pump* (Method 2).

Injection pump must be timed on the compression stroke, not the exhaust stroke.

METHOD 1. DEPTH MICROMETER METHOD

1. Install pump tappet in its recess and position flywheel on port closing mark (PC) of compression stroke.
2. Using a depth micrometer, measure distance from pump mounting pad on crankcase to tappet center. See Figure 3-14.
3. Subtract from the port closing dimension of pump (1.670-inch) the depth obtained in step 2. The result is the thickness of shims necessary to correctly time the pump.

Thickness of shims may vary from 0.006-inch to 0.052-inch. If it does not fall within these limits, check camshaft and tappet for excess wear or improper assembly.

4. Select correct shims for required thickness.
5. Install pump.

METHOD 2. FLOWING THE PUMP

1. Install pump with 0.006-inch (0.152 mm) shims between pump and pad.
2. Loosen delivery valve cap nut and holder to relieve pressure on spring. See Figure 3-15.

TABLE 3-1. SHIM SELECTION

DISTANCE MEASURED STEP 4		ADD THESE SHIMS	
Inch	mm	Inch	mm
0.1	2.54	0.010	0.254
0.2	5.08	0.014	0.355
0.3	7.62	0.018	0.457
0.4	10.16	0.022	0.559
0.5	12.70	0.026	0.660
0.6	15.24	0.030	0.762
0.7	17.78	0.034	0.864
0.8	20.32	0.038	0.965
0.9	22.86	0.042	1.069
1.0	25.40	0.046	1.168
1.1	27.94	0.050	1.270

The PLB injection pump arm must be held on center or to the right of center in order for the fuel to flow through the pump plunger ports to the delivery valve when the transfer pump is operated by hand.

3. Rotate flywheel to about 15 degrees before port closing (PC) point. Operate transfer pump to pump fuel into pump inlet and rotate flywheel slowly clockwise until fuel stops coming out of pump outlet. This is the port closing point.
4. Measure distance from point where port closing occurs to PC mark on flywheel. Find thickness of shims to be added from Table 3-1.
5. Install pump.

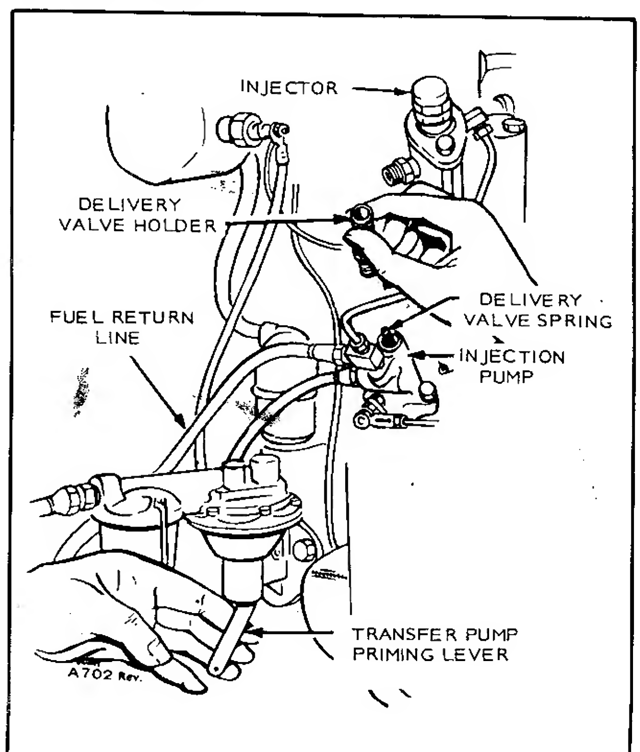


FIGURE 3-15. LOOSENING DELIVERY VALVE HOLDER

INSTALLATION

Prior to mounting the injection pump to the cylinder block, follow steps 1 through 3.

1. Slide shim or shims (using proper thickness of shims for correct timing) over pilot until they are flat on pump flange. See Figure 3-16.

   The shim thickness required for each engine block is established at the factory and is stamped on the block near the injection pump mounting. This measurement applies to a replacement pump as well as the original pump.

2. Dip seal ("O" ring) in engine lubricating oil.
3. Slide seal over pilot until tight against shim or shims.
4. With shims and seal in place, insert pump into cylinder block mounting pad, and insert mounting screws.
5. Torque mounting screws (tighten alternately) to 18-21 foot-pounds (24-29 N•m).
6. Install the fuel inlet line and governor linkage.
7. Bleed the pump and then install the fuel outlet line.

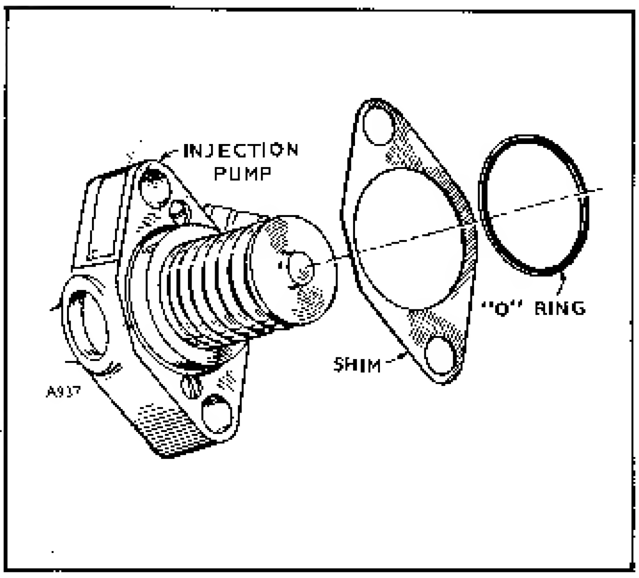


FIGURE 3-16. SHIMMING THE PILOT

PSU INJECTION PUMP

The PSU injection pump (Figure 3-17) is used on Onan 2- and 4-cylinder air-cooled and water-cooled diesels. Pumps that are almost identical with only two injector line outlet ports are used on the two cylinder models. The function of the pump as a distributor and its location on the service side of the engine are the same on both 2- and 4-cylinder engines.

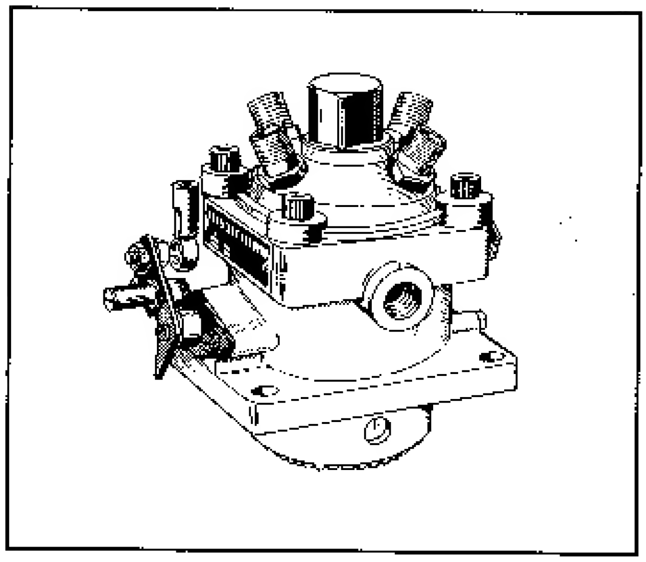


FIGURE 3-17. PSU INJECTION PUMP

PSU Pump Operation

The pump face gear mates with and is rotated by a drive gear on the engine camshaft, Figure 3-18. The face gear, pilot ring, and the reciprocating plunger in the pump are rotated continually to assure positive fuel distribution. The plunger is reciprocated up and down by a multi-lobed cam on the camshaft which bears against a tappet assembly on the pump.

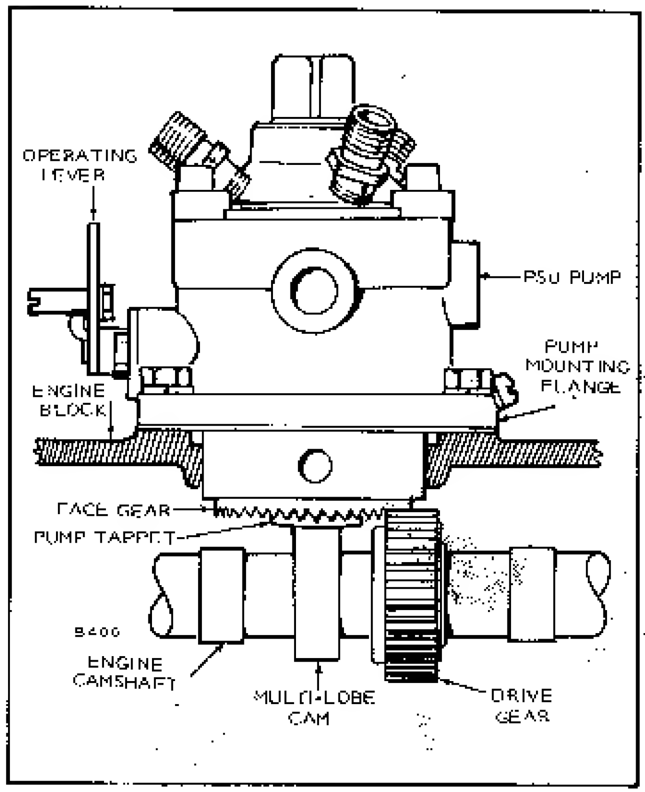


FIGURE 3-18. INJECTION PUMP TO CAMSHAFT RELATIONSHIP

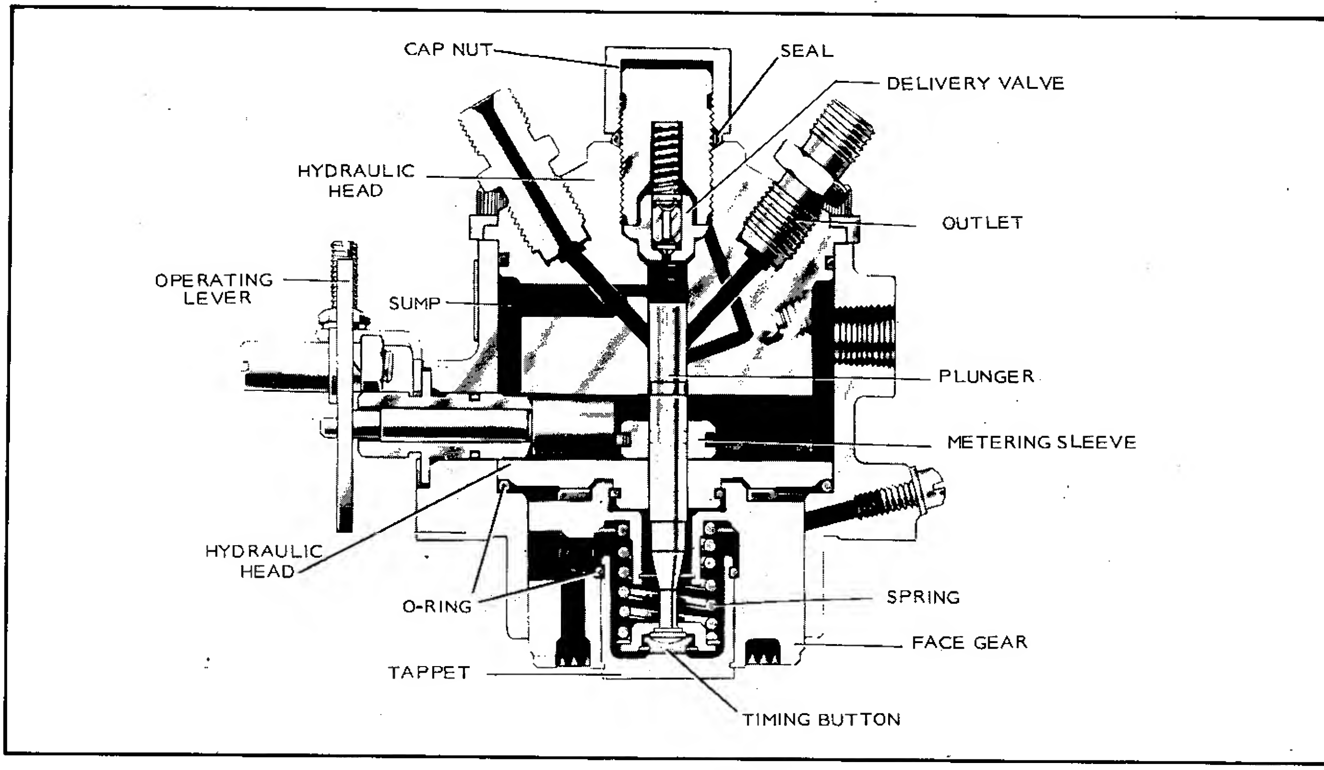


FIGURE 3-19. PSU PUMP (CUTAWAY VIEW)

Pump Cutaway View

The cutaway view in Figure 3-19 shows the control unit operating lever, metering sleeve, delivery valve, plunger and drilled passages to the plunger and injection lines.

A timing button of very precise thickness transmits motion from the tappet to the plunger and adjusts plunger timing for the fuel pumped to each injector during operation. Plunger reciprocation and rotation are so phased that only one fuel injector is served during the affective portion of each plunger up stroke. The high hydraulic pressure developed is required to open the pressure operated fuel injector nozzles which inject the fuel in a fine mist into the combustion chamber. Fuel delivery control, full load, and shutoff are regulated by the up-and-down movement of the fuel metering sleeve. The sleeve is controlled by the operating lever on the outside of the pump. Fuel is injected only during the high velocity portion of each plunger up stroke.

When the tappet slips off each lobe of the camshaft, the spring loaded plunger is forced down opening the fuel supply port to the fuel sump. This allows fuel under low pressure from the transfer pump and fuel sump to fill the cavity between the top end of the plunger and the delivery valve. The plunger is then ready for the up stroke.

Metering Sleeve Operation

The metering sleeve is positioned by the operating lever of the governor control unit, Figure 3-20. An eccentric pin on the end of the control shaft engages a slot in the metering sleeve so that a slight rotation of the control shaft causes the sleeve to ride up or down on the plunger. As the camshaft and face gear rotate, the drive key and a vertical slot in the face gear transmit rotation to the plunger. Rotating the plunger aligns the plunger outlet groove with the proper injection line outlet for the injector to be fired on each pump stroke.

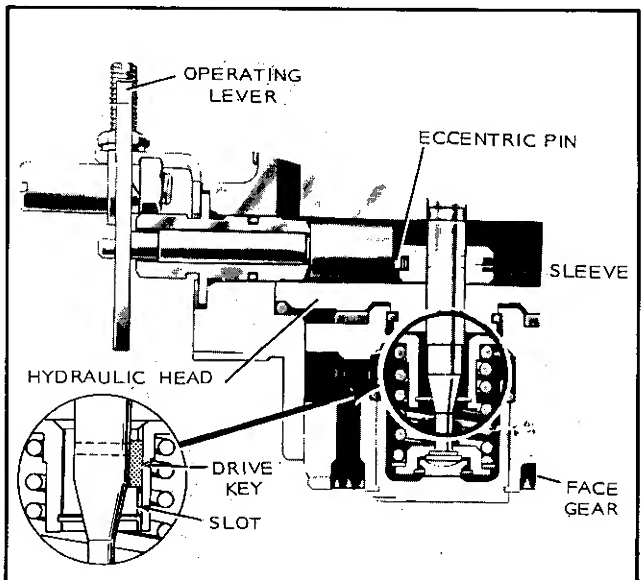


FIGURE 3-20. METERING CONTROL

Plunger and Sleeve Movement

As the plunger is cammed upward, the fuel fill port (A) is closed cutting off the fuel supply to the open center of the plunger, Figure 3-21. This is the critical port closing (PC) point of the injection pump that corresponds with the PC mark on the rim of the flywheel. As the metering sleeve moves upward on the plunger, it closes off the spill port (B). Now, as the plunger moves upward, the fuel trapped above its top end builds up pressure and lifts the delivery valve off its seat and the high pressure fuel is ported via the distributor-groove on the plunger upper end to one injector line. As the plunger reaches the upper end of its movement, the spill port (C) clears the sleeve allowing the high pressure fuel to spill into the sump.

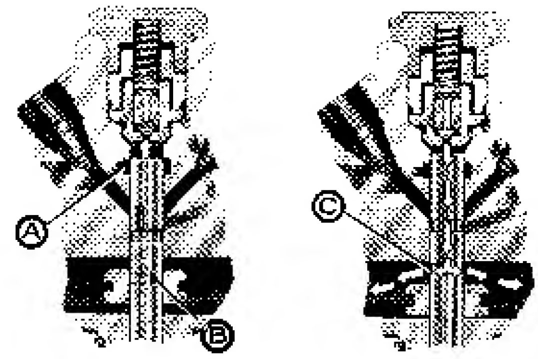


FIGURE 3-21. PORT CLOSING

Sleeve Control

The metering sleeve controls the volume of fuel delivered to the injectors on each stroke of the plunger.

No Delivery: With the metering sleeve in the full downward position, the spill port is open so no fuel is trapped above the plunger. Therefore, no fuel delivery results. As the governor actuates the control shaft to move the metering sleeve upward on the plunger, fuel is trapped above the plunger as the port closes. Fuel delivery corresponds with the load placed on the engine. See Figure 3-22.

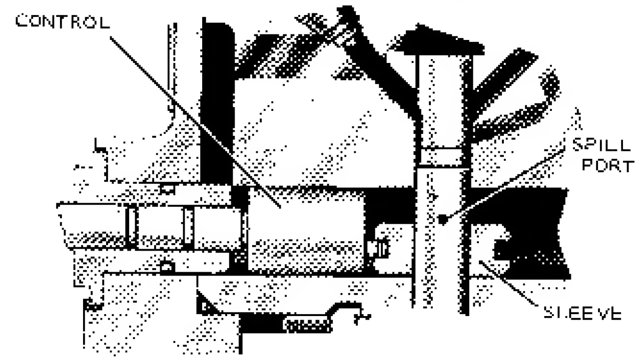


FIGURE 3-22. NO DELIVERY

Normal Delivery: For normal delivery (Figure 3-23) the sleeve moves only part way up before the spill port opens to dump the high pressure.

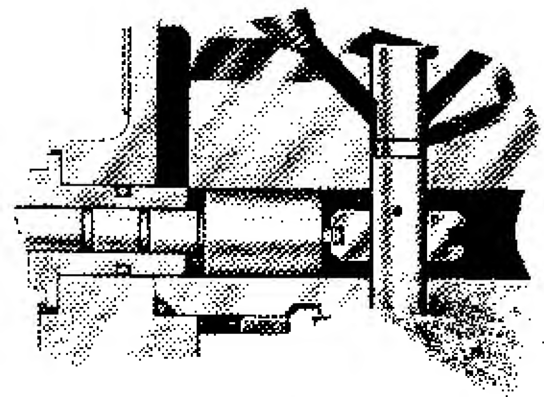


FIGURE 3-23. NORMAL DELIVERY

Maximum Delivery: For maximum delivery (Figure 3-24), the control shaft must position the sleeve fully upward. This increases the fuel delivery time and volume because the spill port doesn't clear the sleeve until a higher portion of the pumping stroke is reached. All engine speed and power control is determined by the governor acting through the control shaft and metering sleeve.

The plunger always makes the same stroke, but varying the position of the metering sleeve regulates the spill port opening, and thus the volume output from the plunger to the delivery valve and injectors.

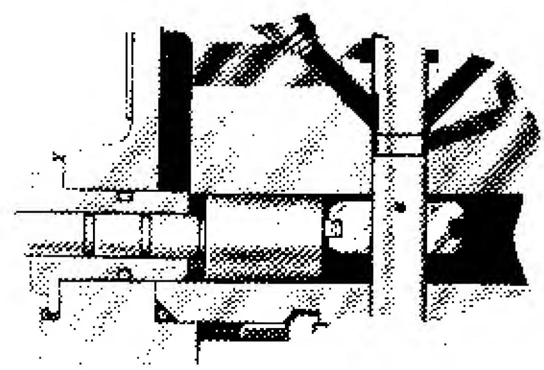


FIGURE 3-24. MAXIMUM DELIVERY

Delivery Valve Operation

The delivery valve assembly regulates flow of controlled amounts of fuel to each injector outlet, Figure 3-25. The valve automatically closes at the end of each plunger stroke due to spring action when the pressure drops at the plunger port.

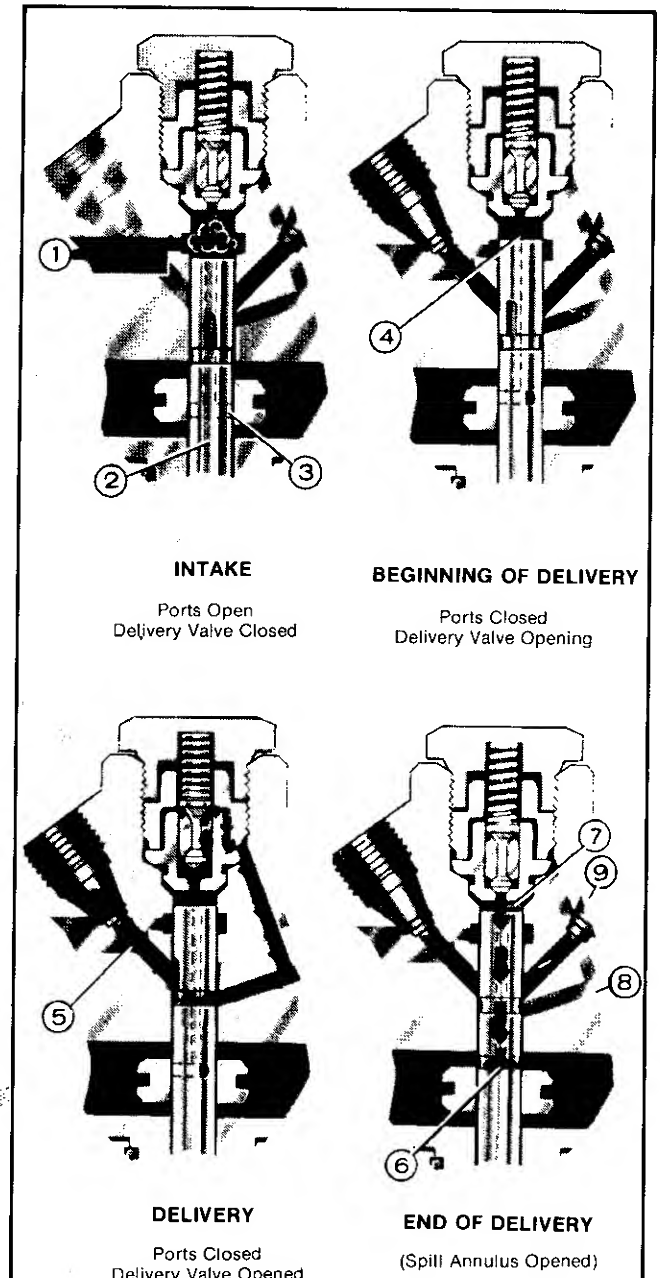


FIGURE 3-25. DELIVERY VALVE OPERATION

Delivery Valve Operating Principles

1. Fuel enters port (1) with rising plunger (2).
2. Notice, spill port (3) is closed.
3. As plunger continues to rise, fill port closes and fuel is trapped above plunger (4).
4. Additional plunger movement opens delivery valve and forces fuel through delivery valve (arrows 5) to outlet for cylinder No. 1.
5. Fuel under high pressure continues to flow with upward movement of plunger until spill port (6) opens. This results in a pressure drop and delivery valve closes (7). Now, residual pressure is trapped in line (8).

Since the plunger is constantly rotating counterclockwise, the above action repeats for cylinder (9) No. 2 when the plunger rotates 180 degrees on next stroke. Injection occurs every 90 degrees of plunger rotation counterclockwise on four cylinder engines.

The relief piston portion of the delivery valve reduces line pressure and automatically provides a sharp cutoff of fuel at the end of each plunger stroke. This prevents secondary injections and nozzle dribble, reduces engine smoke, and prevents nozzle carbonizing.

PUMP COMPONENTS

Figure 3-26 shows the following pump components:

- The plunger tappet assembly.
- The control shaft assembly.
- The pump body.
- The delivery valve assembly.
- The governor stop .

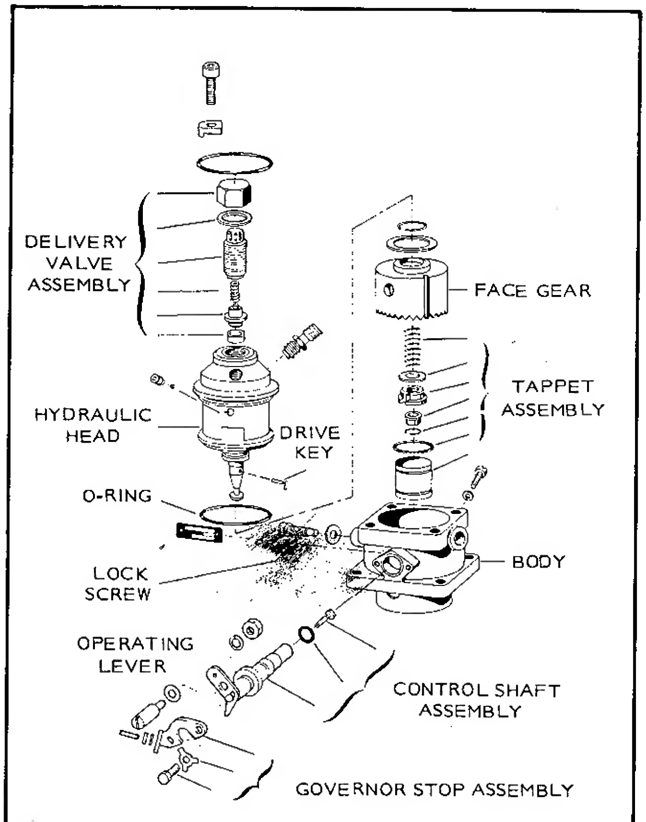


FIGURE 3-26. PSU PUMP (EXPLODED VIEW)

Pump Installation Shims

If the pump is removed from the engine, be sure the steel shims between the pump and the crankcase mounting are the same on reassembly to maintain proper gear backlash, Figure 3-27. The number stamped on the crankcase indicates the proper shim thickness. This thickness does not change when a new pump is installed. It only changes when a new crankcase is installed, and then the thickness of the proper shims is stamped on the new crankcase.

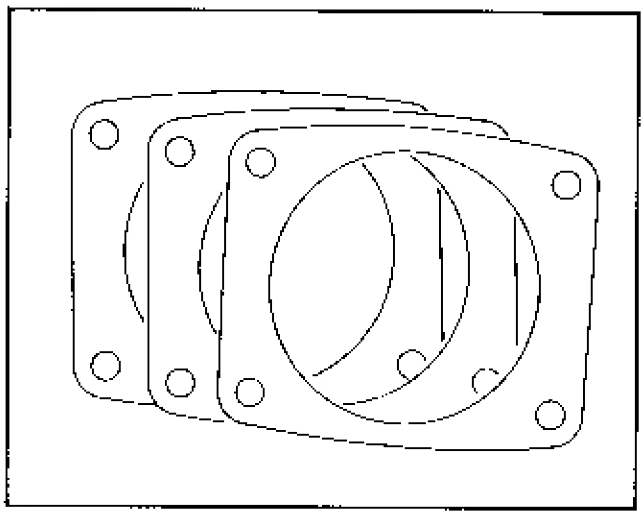


FIGURE 3-27. SHIM THICKNESS

Removing Tappet

CAUTION **Be sure to hold the pump drive securely to the pump body when removing the tappet, Figure 3-28. If not, the pump will come apart and be difficult to reassemble. Also, the metering sleeve may drop off the plunger into the sump when the plunger is removed. If the mechanic is not aware of it, he could put the pump back together, but it will not operate. If the plunger port is not enclosed by the sleeve, there will be no fuel delivery.**

Use a pair of channel lock pliers or a screwdriver to remove the tappet from the O-ring in the drive gear.

Button 12 or M is the mid-range of the button sizes used the most. The button dimension is determined by the number or letter stamped on its side, Figure 3-29.

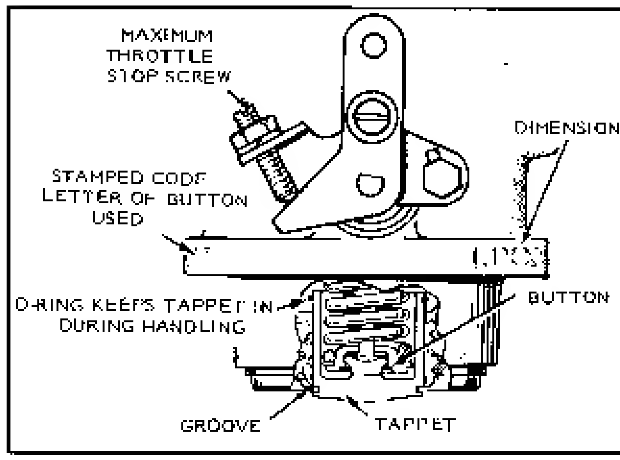


FIGURE 3-28. TAPPET REMOVAL

TABLE 3-2. TIMING BUTTONS

GROUP 1				GROUP 2				GROUP 3			
CODE	PART NO.	SIZE		CODE	PART NO.	SIZE		CODE	PART NO.	SIZE	
		Inch	mm			Inch	mm			Inch	mm
16 or S	147-0186	.134	3.404	1 or A	147-0147	.119	3.023	6 or F	147-0152	.101	2.565
15 or R	147-0187	.131	3.357	2 or B	147-0148	.116	2.946	7 or H	147-0153	.098	2.489
14 or P	147-0188	.128	3.251	3 or C	147-0149	.113	2.870	8 or I	147-0154	.095	2.413
13 or N	147-0189	.125	3.175	4 or D	147-0150	.110	2.794	9 or K	147-0155	.092	2.337
12 or M	147-0190	.122	3.099	5 or E	147-0151	.107	2.718	10 or L	147-0156	.089	2.261
				11 or Std	147-0161	.104	2.642				

Group 1. Used in all late model pumps except 147-0220 (odd firing) beginning Spec R.
Group 2. Used in early models of all pumps.
Group 3. Used in late model 147-0220 (odd firing) pumps.

Pump Kits prior to Spec R—
2 Cyl 147-0218
4 Cyl 147-0231

Pump Kits beginning Spec R -
2 Cyl 147-0219
4 Cyl 147-0232

TIMING BUTTON CODE

The timing button has a code number or letter which corresponds with its dimension in thousands of an inch. See Table 3-2. Figure 3-30 shows the timing button and tappet relationship. Only one button is required to provide the correct port closing.

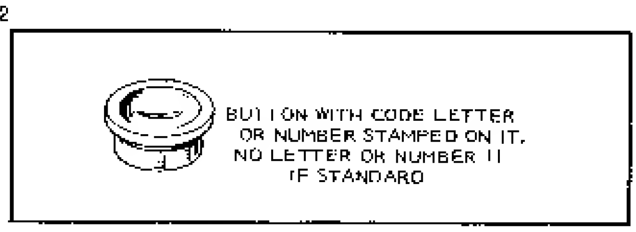


FIGURE 3-29. TAPPET BUTTON CODE

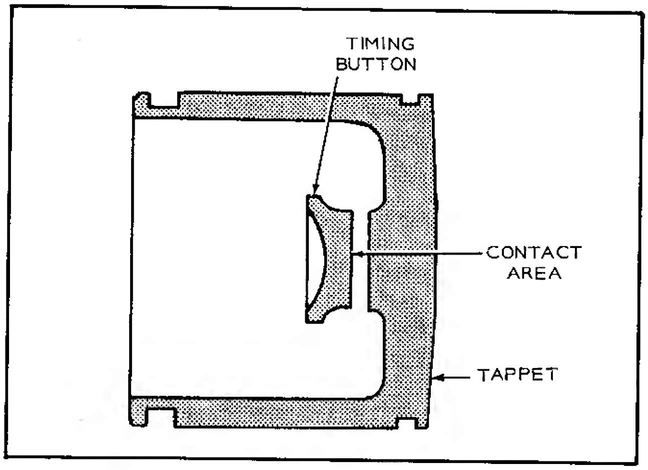


FIGURE 3-30. TIMING BUTTON AND TAPPET

PORT CLOSING FORMULA

The formula for determining the proper port closing (PC) timing button for a new or replacement pump is as follows:

1. Remove old pump.
2. Determine total pump flange and button thickness for old pump.
   a. Write down dimension given on old pump flange. See Example, Figure 3-31.

Formula		Inches	(mm)
Port closing dimension of old pump		1.109	(28.169)
Button thickness of old pump		+.107	(2.719)
	Total	1.216	(30.887)
Port closing dimensions of new pump		-1.094	(27.788)
Required button thickness of new pump		.122	(3.099)

FIGURE 3-31. TIMING BUTTON CALCULATION

   b. Remove old pump timing button.

CAUTION Be careful when removing tappet assembly that the plunger doesn't drop out of the sleeve, because reassembly is difficult.

   c. Obtain dimension of old timing button from Table 3-1 corresponding with number or letter code on timing button.
   d. Add dimension on old pump flange to timing button dimension from Table 3-1.
   e. Write down total PC dimension for old pump.
   f. Write PC dimension from new pump flange and subtract it from total PC dimension for old pump.

Service Bulletin Engine 34 **is enclosed with each new pump to enable the installer to correctly time the pump to the engine. Table 2 lists buttons by Group 1, 2, and 3 codes, part numbers, and dimensions.**

PREPARATION FOR PUMP INSTALLATION

1. The crankshaft must be set on the compression stroke for No. 1 cylinder.
2. Look into hole in block where pump mounts to verify that one intake valve lobe points outward and down 45 degrees.
3. See that PC mark on flywheel aligns with timing pointer on gear case cover, Figure 3-32.
4. Align PC mark on flywheel to timing pointer by rotating crankshaft clockwise in the direction of engine rotation to take out all gear backlash in that direction.

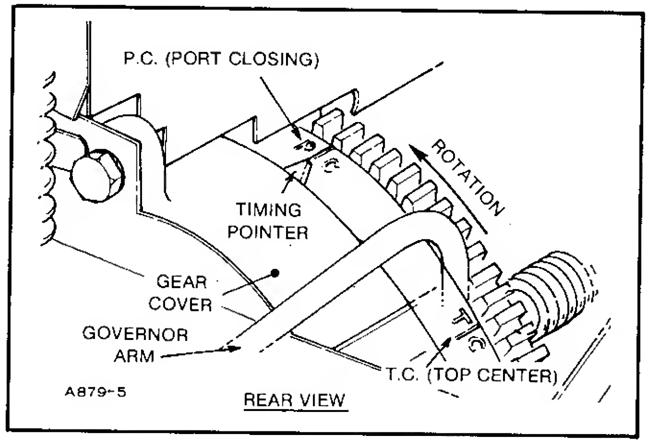


FIGURE 3-32. PORT CLOSING POSITION

POSITIONING PUMP ON ENGINE

Remove the screw shown on the side of the pump, rotate drive gear, and insert a 1/8-inch (3.175 mm) brass rod into the slot in the drive gear to lock the gear for positioning the pump on the engine, Figure 3-33.

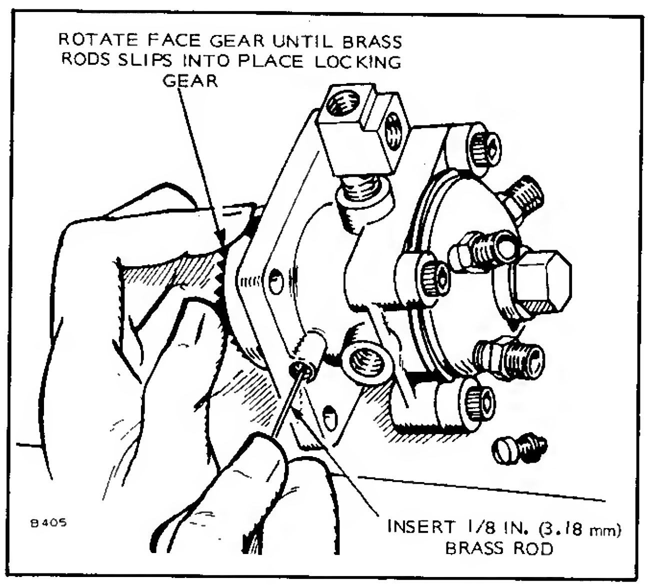


FIGURE 3-33. LOCKING THE DRIVE GEAR

Another method of aligning the drive gear slot for pump installation uses a straight edge as shown. An experienced person can "eye ball" the slot in the screw hole and place the pump on the engine with proper gear teeth meshing.

INSTALLING PUMP

The flat area just above the pump has a number marked on it which refers to the shim thickness required between the pump and its mounting pad for assuring proper backlash in the gearing. Don't forget the shims.

With the pump drive gear locked by the 1/8-inch (3.18 mm) brass rod, position the pump in the hole and firmly apply pressure, Figure 3-34. A slight spring reaction indicates the pump and camshaft gears are meshed. Maintain this pressure, remove brass rod and rotate the crankshaft manually to make sure the gears mesh properly, Figure 3-35.

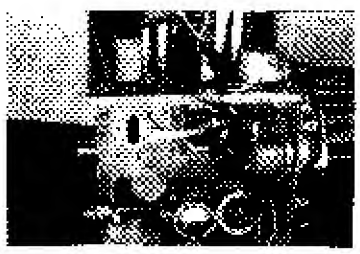


FIGURE 3-34. INSTALLING PUMP ON ENGINE

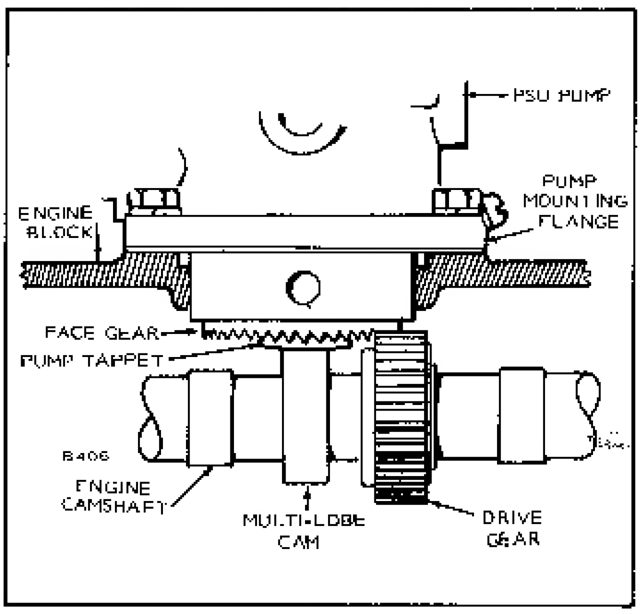


FIGURE 3-35. PSU PUMP INSTALLED

DELIVERY VALVE FUNCTION

The delivery valve maintains 300 to 600 psi (2070 to 4140 kPa) line pressure in the injector lines with the engine running, Figure 3-36. This pressure increases to about 1900 psi (13110 kPa) on each stroke of the injection pump plunger. The trapped fuel is held in the lines at all times, even though the pressure bleeds off during shutdown periods. When the lines are full of fuel, only a couple turns of the crankshaft are required to build up enough line pressure for firing the injectors.

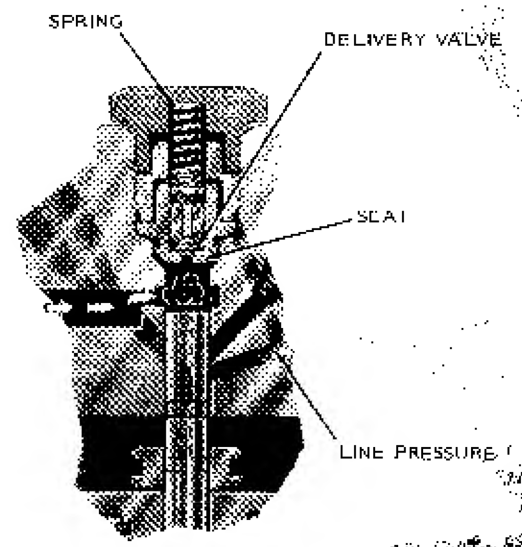


FIGURE 3-36. DELIVERY VALVE CLOSED—PLUNGER DOWN

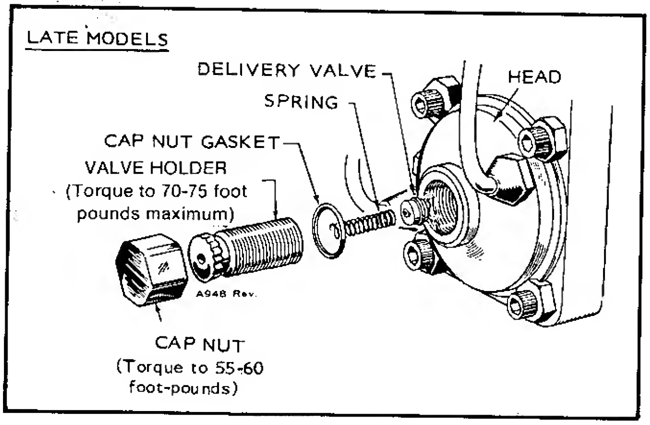


FIGURE 3-37. DELIVERY VALVE ASSEMBLY

FLOW TIMING THE PSU PUMP (DJB-DJC)

Flow timing the injection pump can be done using fuel to determine whether or not the proper timing button has been installed for best operating conditions. In case the pump is removed without recording the PC dimension and the timing button thickness, it is necessary to flow time the pump to establish the exact PC position. Keep everything clean so dust and dirt will not contaminate fuel system.

1. Install No. 12 timing button in PSU pump as previously discussed under preparation for pump installation.
   Remove delivery valve cap and holder; take out spring and replace holder and cap, Figure 3-37.
2. Remove door panel, air cleaner, and top sheet metal cover for access to flywheel marks and fuel system.
3. Remove No. 1 injector line; re-install line with top end of line in pump outlet so other end will direct fuel flow into an open container, Figure 3-38.

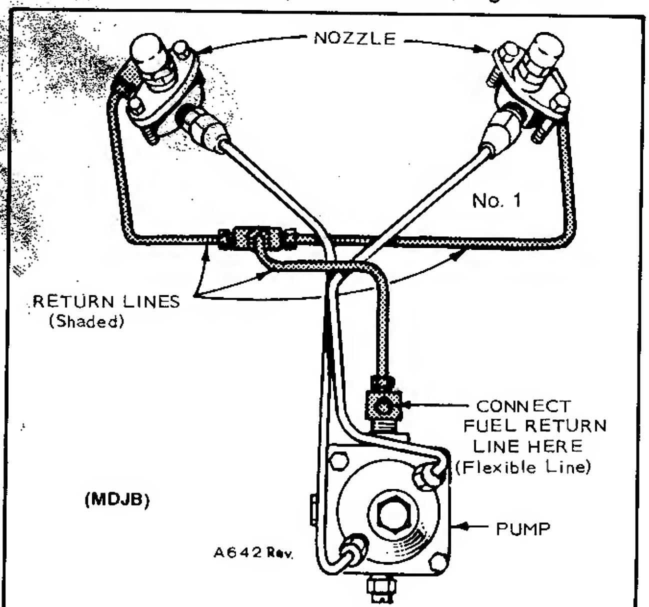


FIGURE 3-38. FUEL LINES TO INJECTORS

4. Place container under open end of No. 1 line.
5. Disconnect governor linkage at ball joint and wedge control arm at maximum fuel position.
6. Rotate flywheel counterclockwise (when facing front of engine) to point where PC mark on flywheel is about 15 degrees before timing pointer (compression stroke No. 1 cylinder).

Check that front cylinder valve rocker arms (both valves) are free to move indicating the valves are closed.

7. Manually operate fuel transfer pump until air-free fuel flows steady from end of No. 1 line into container.

If fuel tank is disconnected, use a separate container of fuel and connect a short hose line between the transfer pump inlet and the fuel container. The pump has enough suction to pull the fuel out of the container.

8. Continue transfer pump operation while assistant rotates flywheel slowly in clockwise direction.
9. Stop flywheel rotation at exact point fuel stops flowing from No. 1 line into container (one drop in 2 to 5 seconds). This point is the port closing time of the injection pump plunger regardless of flywheel position, Figure 3-39.

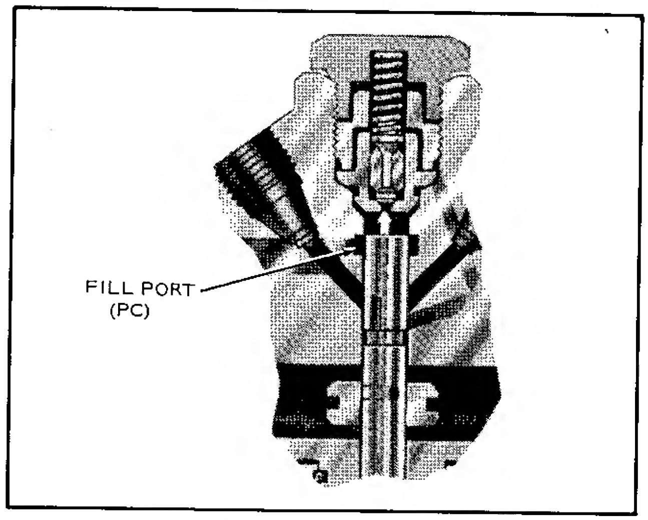


FIGURE 3-39. PORT CLOSING

Timing is correct if port closing occurs when the PC mark on the flywheel aligns with the timing pointer. If it doesn't match, timing is either early or late and another timing button is required, Figure 3-40.

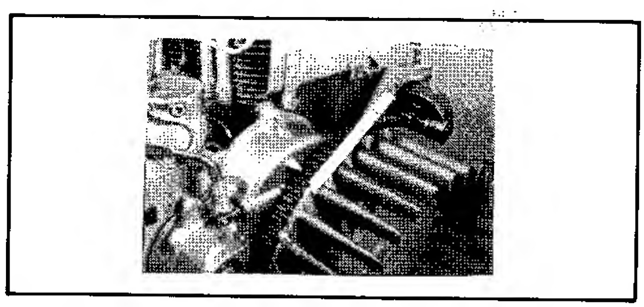


FIGURE 3-40. PORT CLOSING (PC) MEASUREMENT

TIMING BUTTON THICKNESS

Injection pump kits include a pump and four buttons which will time 90 percent of the engines. The standard thickness button and ring spring are no longer assembled, but are loose in kit.

Pump timing is critical. The injection pump on each engine must be timed to that particular engine by using a timing button of specific thickness. Use the method which applies best to determine the correct new button thickness. Each new pump has its own port closing dimension stamped on it.

Procedure

1. Mark flywheel in 0.1-inch (2.54 mm) graduations (about five marks each direction) from PC mark for calculating required change in button thickness.
2. Measure distance in tenths (or mm) from PC mark on flywheel to point of actual port closing.
3. Multiply distance measured times .003 inch (.076 mm) to determine the difference in thickness required for new button.

One degree of crankshaft rotation equals the 0.1-inch graduation or .003-inch button thickness for timing.

TIMING CALCULATION

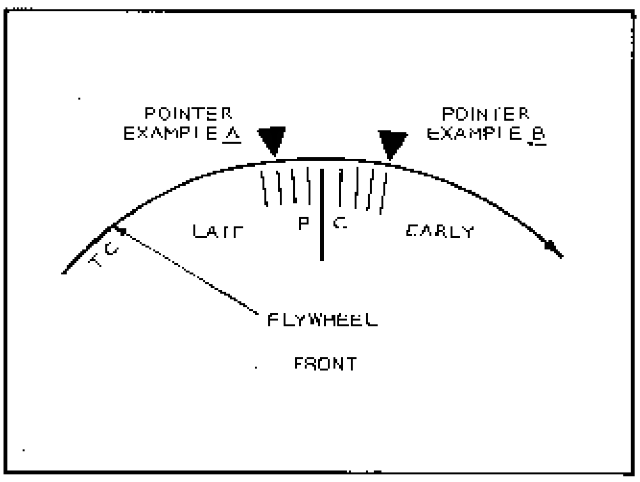


FIGURE 3-41. TIMING MARKS

Example A. The port closing time *is late* by 0.3-inch (7.6 mm) measurement, Figure 3-41.

3 x .003" = .009"
(3 x .076 = .228 mm)

Since .1 inch (2.54 mm) equals .003 inch (.076 mm) button thickness, the installed button is too thin by .009 inch (0.228 mm). This means a button .009 inch (0.228 mm) thicker than the one installed is required to time port closing so PC mark on flywheel aligns at the timing pointer when fuel flow stops.

Example B. If PC timing is *too early* by 0.4 inch (10.2 mm), multiply 4 x .003 = .012 inch (4 x 7.6 mm = 0.305 mm). In this case, a thinner button .012 inch (0.305 mm) less than the one installed is required.

BLEEDING FUEL SYSTEM

Bleed fuel system whenever the filters are changed or when there is air in the lines.

Procedure:

Manually actuate fuel transfer pump until air bubbles are all out and clear fuel flows from the bleed valve automatically, Figure 3-42.

If the transfer pump cam lobe is on the high side, the priming lever will not operate the pump. Rotate the flywheel one revolution before operating the priming lever.

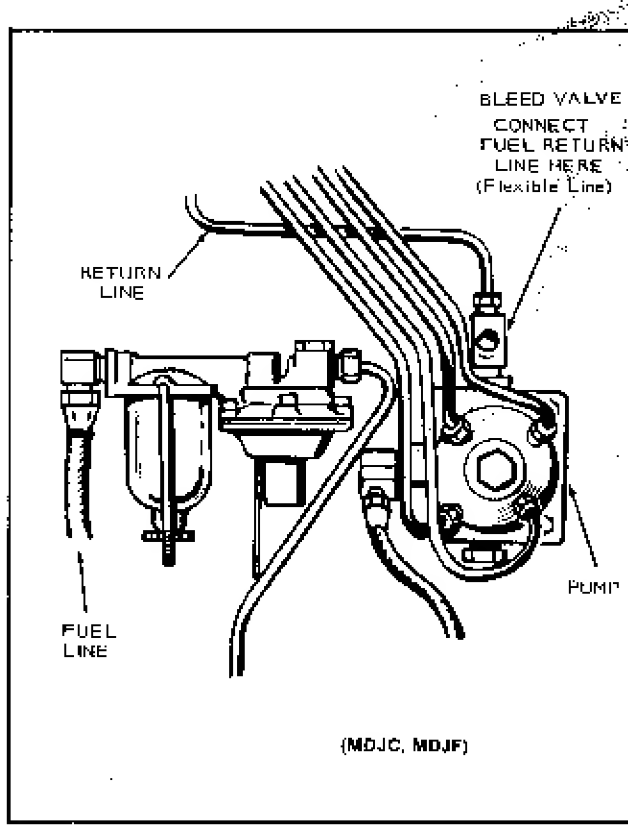


FIGURE 3-42. BLEEDING FUEL SYSTEM

BRYCE/KIKI FUEL SYSTEM

The Bryce or Kiki fuel injection system (Figure 3-43) is located near the center on the left side of the engine crankcase on MDJE Spec AB or later engines. The pump is mounted on an adapter casting and two lobes of the cam shaft operate the pump plungers, one plunger and cam lobe for each cylinder. The fuel is pumped at high pressure by the plungers through the delivery valves to the injection nozzles.

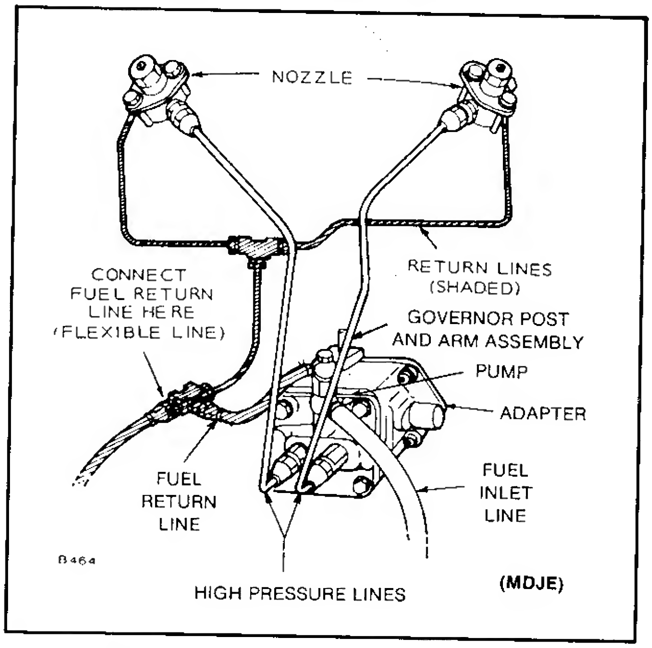


FIGURE 3-43. FUEL LINES TO INJECTORS

The Bryce/Kiki injection pumps operate on the same pumping and metering principles as the American Bosch PLB pump described earlier in this section. Fuel control from idle to maximum speed and power is accomplished by rotating the helix on each pump plunger. Both pump plungers and barrel assemblies are rotated (0 to 180 degrees) by a fuel control arm, yoke, and a rack gear. Rotating the reciprocating plunger changes the effective length of the plunger strokes and hence the amount of fuel it delivers to the injection nozzle.

The fuel transfer pump and the primary and secondary fuel filters in this system are identical to those described for and used on the other DJ-series engines.

NOZZLES

The MDJE fuel injection systems use Diesel Kiki and C.A.V. throttling-pintle type nozzles. The nozzle holders are either Yanmar or Diesel Kiki and have a plated nozzle retaining nut that distinguishes them from Bosch nozzle holders which have a black oxide finish. The nozzle tips are inter-changeable in Kiki and Yanmar holders, but internal components of these holders are not inter-changeable. The opening pressure for new nozzles should be 2133 to 2204 PSI (14707-15196 kPa).

HIGH PRESSURE INJECTION LINES

Both high pressure fuel lines between the injection pump and the two nozzles are designed to be installed without any bending. Lines that fit on Bryce pump installations also fit on Kiki pump installations, and vice versa. Whenever the lines must be removed, disconnect both ends. Do not bend the lines.

BLEEDING FUEL SYSTEM

After replacing or cleaning the filters, bleed the fuel system of air. Bleed air from fuel system as follows:

1. Disconnect fuel return line at the tee near the transfer pump. Use container to catch fuel.
2. Operate hand priming lever on diaphragm type fuel transfer pump until there are no air bubbles in fuel flowing from the fuel return line, Figure 3-44.

If fuel tank is disconnected, use a separate container of fuel and connect a short hose line between the transfer pump inlet and the fuel container. The pump has enough suction to pull the fuel out of the container.

If the camshaft's transfer pump lobe is up, crank engine one revolution to premit hand priming. When finished, return priming lever inward (disengaged position) to permit normal pump operaton.

3. Then connect the fuel return line at tee.

CAUTION **A diesel engine cannot tolerate dirt in the fuel system. It is one of the major causes of diesel engine failure. A tiny piece of dirt in the injection system may stop your unit. When opening any part of the fuel system beyond the secondary fuel filter, place all parts in a pan of clean diesel fuel as they are removed. Before installing new or used parts, flush them thoroughly, and install while still wet.**

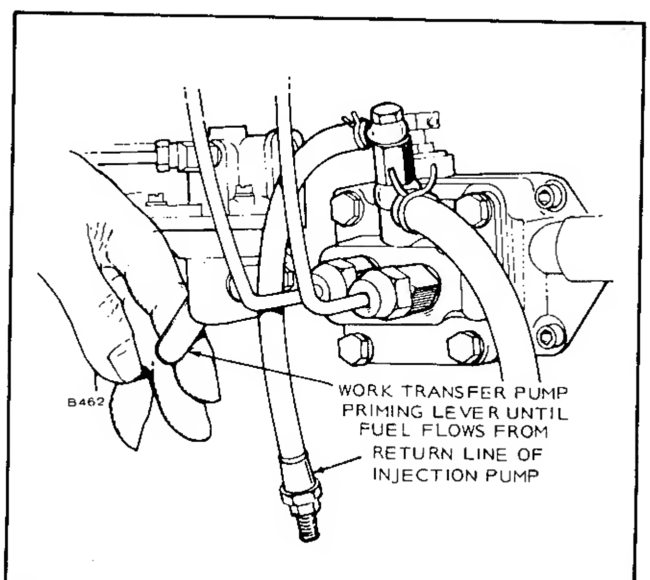


FIGURE 3-44. BLEEDING FUEL SYSTEM

BRYCE/KIKI FUEL INJECTION PUMPS

The Bryce/Kiki Injection Pumps are similar in design, appearance, and performance, Figure 3-45. Both units mount two plunger and barrel assemblies in a single housing and use a common rack (gear) to rotate the control sleeves and regulate the fuel output of both pumps. These pumps are interchangeable on MDJE engines. Internal components of the Bryce and Kiki Pumps are not interchangeable. One external difference is that the Bryce Pump uses an alignment dowel pin to fit it on the adapter assembly.

The delivery valves on both pumps are also similar, but the Bryce has one copper sealing gasket while the Kiki uses a combination sandwich type seal that requires a special delivery valve pulling tool to remove it.

Both pumps use roller type tappets as cam followers which are held in place by pins and lock wire. Each pump has an air bleed fitting to vent air and allow for easy priming.

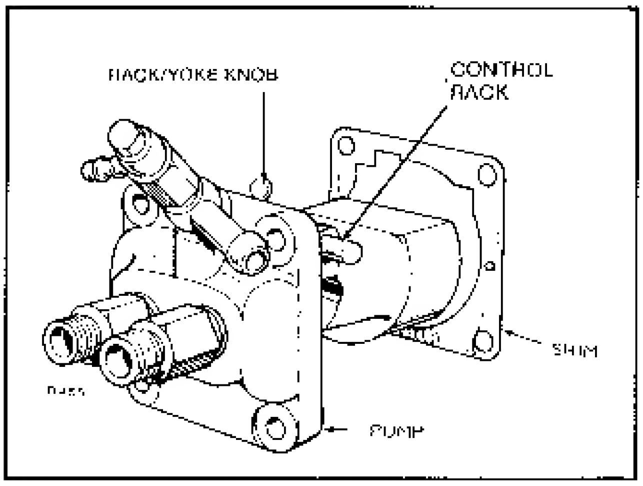


FIGURE 3-45. INJECTION PUMP

INJECTION PUMP ADAPTER

This cast iron adapter (Figure 3-46) is the crankcase mounting fixture for the fuel injection pump and its fuel control arm and yoke and the overfueling control device. A composition gasket is used between the adapter and the crankcase.

The fuel control arm and the shaft and yoke assembly transmit governor action to the injection pump control rack. The overfueling device provides maximum (excess) fuel during engine starting, and limits the maximum amount of fuel and engine power output to protect the engine from excessive loading.

CAUTION **Do not change the adjustment of this device unless absolutely required. The warranty may be voided, if the fuel stop is intentionally altered to increase engine power above 10 percent overload at rated speed and load.**

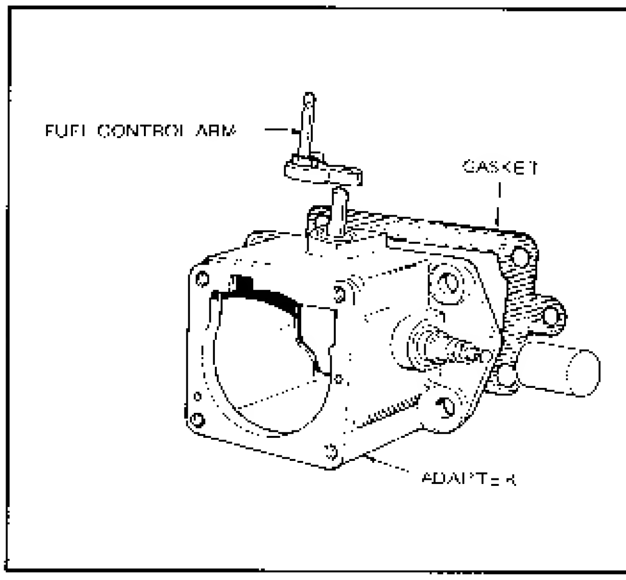


FIGURE 3-46. ADAPTER ASSEMBLY

INJECTION PUMP REPAIR

Most fuel system troubles are not due to a faulty injection pump; test the rest of the fuel system before condemning the injection pump.

Onan discourages field repair of the injection pump because of the exceptionally close tolerances between parts and the specialized equipment necessary for repair. The injection pump is an expensive part of the unit and even a particle of dirt as fine as talcum powder could score its working surfaces.

INJECTION PUMP REMOVAL

If the rest of the fuel system is in working order and fuel delivery abnormal, remove the pump for replacement or repair.

1. Locate injection pump on service side of engine and remove necessary sheet metal and hardware to make pump accessible.
2. Remove fuel inlet and return line, Figure 3-43.
3. Remove high pressure lines between pump and injector nozzles, both ends.
4. Cap all lines and fittings using extreme care to keep all fuel system components clean.
5. Remove four socket head screws holding pump to adaptor assembly.
6. Position fuel control shaft and yoke as shown in Figure 3-47. Then, lift pump off of adapter assembly.
7. Carefully clean injection pump assembly and place it in a clean place. Retain shims between pump and adapter as they are needed for reassembly.

CAUTION A diesel engine cannot tolerate dirt in the fuel system. It is one of the major causes of diesel engine failure. A tiny piece of dirt in the injection system may stop your unit. When opening any part of the fuel system beyond the secondary fuel filter, place all parts in a pan of clean diesel fuel as they are removed. Before installing new or used parts, flush them thoroughly, and install while still wet.

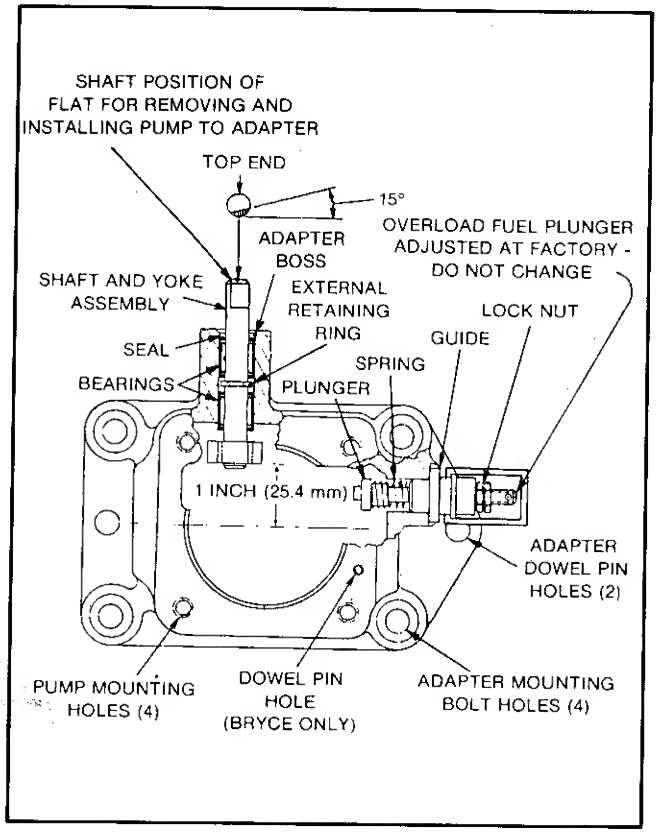


FIGURE 3-47. INJECTION PUMP ADAPTER ASSEMBLY

ADAPTER ASSEMBLY REMOVAL

1. Remove fuel control arm.
2. Remove four mounting bolts and lift adapter assembly off of engine block. It may be necessary to tap assembly with lead or plastic hammer in order to loosen adapter from gasket.
3. Discard old gasket and clean area on engine block. A new gasket is required for reassembly of adapter to prevent oil leaks.
4. Thoroughly clean adapter assembly before replacing new bearings and oil seal.
5. Place adapter assembly in suitable holder for removing and installing bearings and seal.

CAUTION Do not clamp in a vise unless machined surfaces are protected from damage by the jaws of the vise.

BEARING AND SEAL REPLACEMENT PROCEDURE

After adapter assembly has been removed from the engine, replace the bearings and seal on the yoke shaft as follows:

1. Referring to Figure 3-48, press shaft and yoke assembly towards center of adapter until shaft and bottom bearing slips out bottom end.

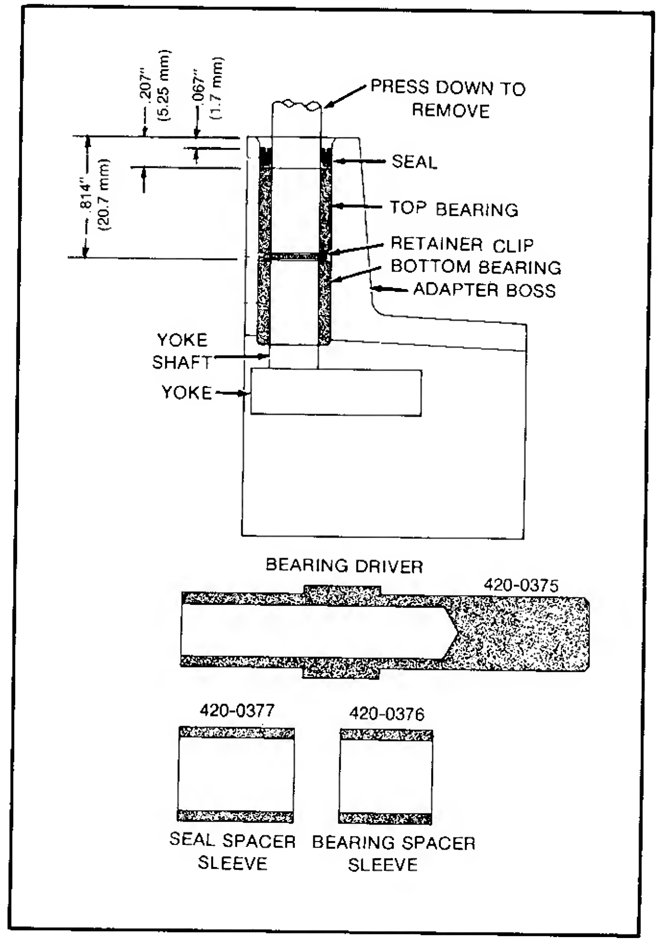


FIGURE 3-48. BEARING INSTALLATION AND TOOL PACKAGE (420-0374)

2. Using solid end of bearing driver, press top bearing and seal out bottom end.
3. Remove external retaining ring and slide bearing off yoke shaft.
4. Thoroughly clean and oil yoke and shaft assembly and adapter for installing new bearings and seal.
5. Install bottom bearing from top of adapter casting using hollow end of bearing driver. Make sure "lettered" side of bearing faces upward and that tool bottoms against top of adapter boss.
6. Slide yoke and shaft assembly up through bearing, then support yoke and shaft assembly for installing the retaining ring.

7. Using hollow end of bearing driver, press retaining ring on shaft, far enough so ring snaps into groove on shaft.
8. Slide bearing spacer sleeve (shortest sleeve) over hollow end of bearing driver; then use tool to press top bearing into adapter. Make sure tool bottoms against top of adapter boss and that "lettered" side of the bearing faces upward.
9. Replace bearing spacer sleeve with seal spacer sleeve (longest sleeve) and then use tool to press oil seal over shaft at top of adapter. Make sure seal is installed with "lettered" side down, facing the bearing, and that tool bottoms against top of adapter boss.
10. Reinstall adapter and injection pump assemblies.

ADAPTER INSTALLATION

Proceed as follows:

1. Place new gasket on engine block dowel pins and install adapter using four socket head screws and lock washers; torque screws to 20-24 ft. lb. 27-33 N•m).
2. Determine shim thickness required between pump and adapter because the new gasket may not be the same thickness as the original one. See Figure 3-49.

The proper shim thickness is stamped on the block for the shim combination required during the original factory installation of the injection pump.

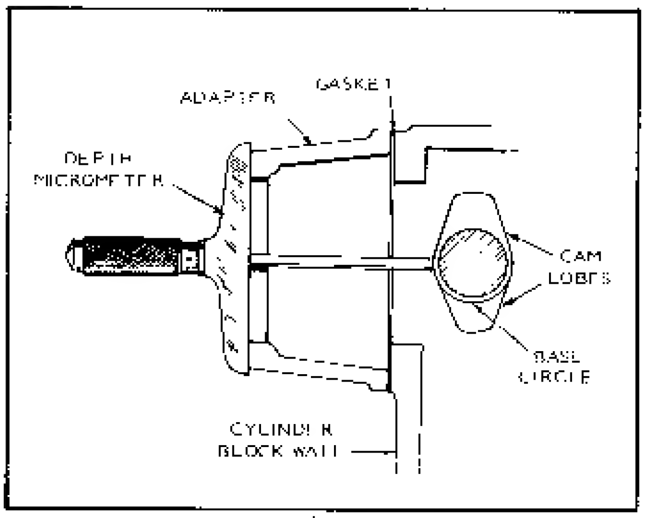


FIGURE 3-49. MEASURING DEPTH FOR SHIM THICKNESS

3. To measure for shim thickness:

   a. Rotate crankshaft to position injection pump cam lobes on the camshaft in a vertical position so the base circle of each lobe faces the adapter opening.

   b. Using a depth micrometer, measure the distance from the mounting face of the adapter to the base circle of either cam lobe.

   The shim kit contains shims in the following thicknesses: .002, .003, .005, .010, .014, and .018 inches. If one shim is not enough, the required shim thickness (between .004 and .020) can be obtained within .001 inch by combining two of the above shims. The thickness is stamped on each shim. For the greatest accuracy, measure the total shim thickness with a micrometer.

4. To calculate the shim thickness, use the following formula:

   Standard installation depth
   of pump is . . . . 3.2598 *inches (82.8 mm)
   Distance from adapter flange to cam lobe base circle as measured
   (subtract from above) _____ inches (mm)
   Required shim
   thickness = _____

*Many earlier spec AB MDJE engines have an installation dimension of 3.2540 (82.652 mm). On these units, a silkscreen print indicates this dimension. If so, 3.2540 should be substituted for 3.2598 in Step 4.

INJECTION PUMP INSTALLATION

Install injection pump on adapter assembly as follows:

1. Rotate crankshaft to position camshaft so that the pump rollers contact the camshaft base circle (low point of the pump cam lobes). One lobe should be up, the other lobe down. See Figure 3-49.
2. Using proper shim thickness (Figure 3-50), install pump to adapter with four socket head capscrews and lockwashers. Torque to 20 to 24 ft-lbs 27-33 N•m).

CAUTION **Be sure the control rack ball fits between the yoke fingers for proper operation. If the rack ball is not properly placed in the yoke, engine operation will be uncontrollable and must be stopped immediately. In such as emergency, the engine can be stopped by blocking the air intake, or by loosening (just cracking) the fuel injector line fittings at the pump end.**

3. Connect flexible fuel inlet line to pump inlet.
4. Connect each high pressure fuel line to proper pump outlet and nozzle inlet. Torque nuts to 16-18 ft. lb. (22-24 N•m).
5. Reinstall fuel control arm on yoke and shaft assembly, Figure 3-50. Tighten socket head screw, but do not over tighten.

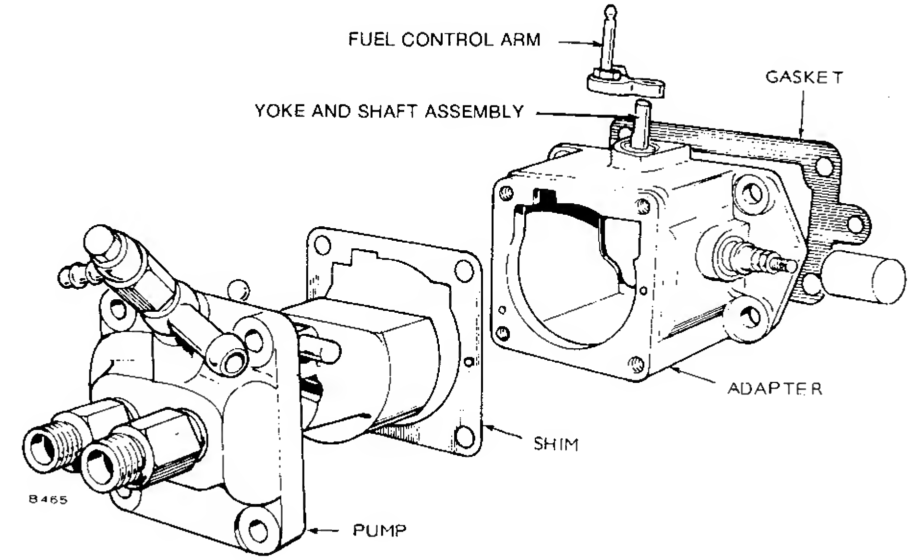


FIGURE 3-50. PUMP AND ADAPTER ASSEMBLY

6. Adjust fuel solenoid plunger so that a 0.010 to 0.030 inch (0.25 to 0.76 mm) clearance exists (see Figure 3-51) between the plunger adjustment screw and the fuel control arm with the solenoid in deenergized position. To adjust the plunger length, hold the plunger, and adjust the screw on the plunger lever pin at the fuel shutoff position. Retighten locknut.

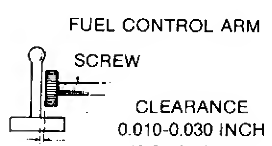


FIGURE 3-51. FUEL SOLENOID ADJUSTMENT

FLOW TIMING - TROUBLESHOOTING ONLY

Flow timing is performed at either injection line to establish or confirm the port closing (PC) point of each fuel injection cycle. The PC point should be about the same for each cylinder, but an allowable difference between cylinders is 2.5 crankshaft degrees of rotation measured on the flywheel rim. Approximately 0.1-inch (2.54 mm) is equivalent to 1-degree rotation. At 1500 and 1800 rpm, PC should occur at 18° BTC ± 4° on MDJE engines.

If piston drop is measured to determine the PC point, the nominal value is 0.115 inch (2.9 mm); the allowable range is 0.171 to 0.070 inch (4.3 to 1.8 mm).

FLOW TIMING PROCEDURE

To determine PC, proceed as follows:

1. Remove one high pressure line (both ends), and the corresponding delivery valve holder, spring, volume reducer, and delivery valve, Figure 3-52. Leave gasket and seat in pump.

Place the spring and volume reducer in a clean container of fuel until re-installed.

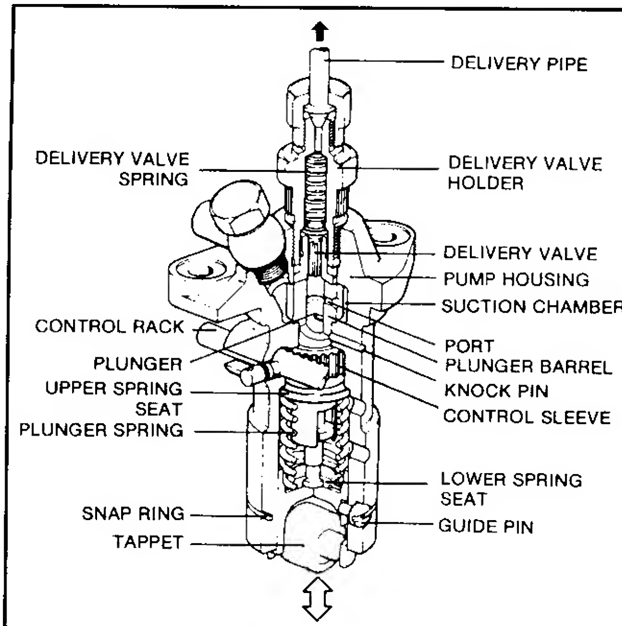


FIGURE 3-52. SINGLE INJECTION PUMP ASSEMBLY